

ORIENTATION-ERROR ACCIDENTS IN REGULAR ARMY AIRCRAFT
DURING FISCAL YEAR 1971: RELATIVE INCIDENCE AND COST

W. Carroll Hixson and Emil Spezia



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13. ABSTRACT This report is the fifth in a longitudinal series of reports dealing with the pilot disorientation/vertigo accident problem in Army fixed wing and rotary wing flight operations. Incidence and cost data presented for fiscal year 1971 include a total of 50 major and minor orientation-error accidents (25 of which were fatal), resulting in 65 fatalities, 67 nonfatal injuries, and an over-all aircraft damage cost of \$11,404,119. The contribution of rotary wing accidents to this total was 47 accidents (23 of which were fatal), resulting in 62 fatalities, 67 nonfatal injuries, and an over-all aircraft damage cost of \$11,191,377.		

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SUMMARY PAGE

THE PROBLEM

From the military mission viewpoint, the amount of research effort to be expended on the solution of a given aviation medicine problem must be keyed to the operational cost of the problem. Therefore, a necessary first step in the development of a solution is the assimilation of data that define the magnitude of the problem. Though orientation-error accidents involving pilot disorientation and vertigo have been long recognized to exist, little quantitative data are available to describe the actual incidence and cost of such accidents in Army aviation.

FINDINGS

To initiate the action necessary to establish the magnitude of the orientation-error problem in Army aviation, an interservice research program was organized under the joint sponsorship of the U. S. Army Aeromedical Research Laboratory, the U. S. Army Agency for Aviation Safety, and the Naval Aerospace Medical Research Laboratory. The first step was the construction of an operational definition of an orientation-error accident. The assimilation of data pertaining to the incidence and cause of such accidents and their actual and relative costs in terms of fatalities, injuries, and aircraft damage was then set as the working objective program. Accordingly, the decision was made to implement a five-year longitudinal study of all major and minor orientation-error accidents involving Regular Army flight operations beginning with fiscal year 1967. Findings are being summarized on a fiscal-year basis in three separate lines of reports: The first line is devoted to defining the over-all magnitude of the orientation-error problem in all aircraft types; the second line to the presentation of similar incidence and cost data for accidents involving only the UH-1 aircraft, the predominant rotary wing aircraft in the Army inventory; and the third line to the description of the various causal factors found to be present in the major UH-1 orientation-error accidents.

This specific report is the fifth in the series dealing with the over-all magnitude of the orientation-error problem in all aircraft types. Incidence and cost data are presented for all Regular Army major and minor orientation-error accidents detected in the search of the fiscal year 1971 accident files. Separate and totaled statistical data are provided for fixed wing and rotary wing aircraft as well as for accidents occurring in Vietnam and those occurring elsewhere.

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The findings in this report are not to be construed as an official Department of the Army position, unless so designated by other authorized documents.

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INTRODUCTION

To investigate the operational role of pilot disorientation and vertigo in the production of orientation-error type aircraft accidents, the authors have organized an interservice research program under the joint sponsorship of the U. S. Army Aeromedical Research Laboratory (USAARL), the U. S. Army Agency for Aviation Safety (USAAAVS), and the Naval Aerospace Medical Research Laboratory (NAMRL). Since little quantified data were available to describe the actual magnitude of the orientation-error problem in Regular Army flight operations, the decision was made to conduct a five-year longitudinal study, beginning with fiscal year 1967, of all Army aircraft accidents that involved an erroneous judgment of aircraft motion or attitude on the part of the pilot. Two separate, but related, project objectives were set for the longitudinal study. The first was to extract and assimilate data from the USAAAVS master aircraft-accident files which would define the actual and relative cost of orientation-error accidents to Regular Army flight operations. These data, by defining the operational magnitude of the problem, would then serve to define the extent of the research support which should be devoted to its solution. The second working objective was to extract data on a case-history basis which would describe the various pilot/aircraft/mission/environment factors found to be present in each of the orientation-error accidents. Assimilation and analysis of these data over the study period would result in better knowledge of the most common operational causes of orientation-error accidents and thus point out those research directions which offer the greatest potential toward the reduction of accident incidence.

The results of the longitudinal study are being summarized in three separate lines of reports, with one report in each line prepared for each fiscal year of the five-year study. The first line of reports (for example, ref. 1) is devoted to defining the incidence and cost of all major and minor orientation-error accidents involving all aircraft types, fixed wing as well as rotary wing, that occurred in Regular Army flight operations for each fiscal year. Since the UH-1 "Huey" helicopter has been, and is, the predominant aircraft in the Army rotary wing inventory, the second line of reports (for example, ref. 2) is devoted to defining the magnitude of the orientation-error accident problem in only this aircraft. The layout and format of this line of reports are almost identical to those of the first line. The third line of reports (for example, ref. 3) deals exclusively with the various causal factors found to be present in all of the major UH-1 orientation-error accidents. Typical data to be presented include phase of flight, time of day, type of mission, pilot experience, physiological factors, psychological factors, facility factors, environmental factors, and the like.

This specific report is the fifth in the series dealing with the magnitude of the orientation-error problem in all types of aircraft. Incidence and cost data are presented for all major and minor orientation-error accidents involving all Army Aviation flight operations, other than those of the Army National Guard or Army Aviation Reserve, that occurred during fiscal year 1971. In addition, corresponding cost data are presented for all accident types, regardless of cause, and for pilot-error accident types so as to better establish the relative magnitude of the orientation-error problem.

PROCEDURE

A basic requirement for the commencement of this study was a workable definition of the class of accidents to be defined as involving orientation error. The reader is referred to previous reports (refs. 1,2,3) for a comprehensive definition and discussion of its rationale. Briefly, orientation is considered to involve the correct determination of the dynamic position and attitude of an aircraft in three-dimensional space. The key word here is dynamic, which implies that full knowledge of the motion as well as static attitude and position is required to define its instantaneous spatial orientation. Accordingly, a pilot is considered to have made an orientation error whenever his perception of the motion and attitude of his aircraft differs from the true motion or attitude; i.e., the true orientation of the aircraft. An orientation-error accident is then defined as one that occurs as a result of an incorrect control or power action taken by a pilot (or a correct action not taken) due to his incorrect perception of the true orientation of his aircraft.

With this definition of orientation-error accidents serving as a classification reference, an experienced classifier read all briefs in the USAAVS master accident files and selected all major and minor accidents of this type occurring during fiscal year 1971. For redundancy, the entire accident files were also searched by sifting the coded summaries that USAAVS prepares for each accident for a wide range of indicator terms.

The authors then reviewed the accident briefs independently for the purpose of establishing whether or not an orientation-error accident classification would result. In addition, the comprehensive master file on each suspect accident was obtained and reviewed. Whenever there was serious question as to the contribution of orientation error to the accident or where equally weighted alternative causal factors were present, then the accident was not included in the classification. The net effect of this policy is to give a conservative estimate of the magnitude of the orientation-error accident problem.

RESULTS AND DISCUSSION

The reader is referred to the first report (ref. 1) of this series for details pertaining to the format selected to summarize the accident statistics on a fiscal year basis. Briefly, the format is keyed to providing a cursory review of the incidence and costs of aircraft accidents in general so as to place better perspective on the actual operational magnitude of the orientation-error accident problem. To establish this background, the first section to follow is devoted to describing the over-all cost of all Army Aviation aircraft accidents, regardless of type or location, that occurred during fiscal year 1971. In a second section, equivalent data in a nearly identical format are presented to separately identify those accidents in the first section that were classified by USAAVS as involving one or more pilot-error factors. Cost statistics pertaining to only orientation-error accidents are then presented in a third section. By using these three sets of data as independent references, it then becomes possible to establish some quantitative

insight into the relative, as well as actual, cost of orientation-error accidents in Army Aviation flight operations. Selected comparative relationships of this type are presented in the last section of the report.

For convenience to the reader wishing to make a point-by-point comparison of the fiscal year 1971 accident statistics with the statistics for other fiscal years of the study, the layout and numbering of all tables and figures contained in this report follow identically those presented previously (refs. 1,4,7,10).

ALL TYPES OF AIRCRAFT ACCIDENTS

The data presented in this section describe the incidence and cost of all major and minor aircraft accidents involving all Regular Army flight operations during fiscal year 1971. Separate data groupings are provided for accidents involving only fixed wing (FW) aircraft, only rotary wing (RW) aircraft, and their combined total. In addition, for each of these three statistical groupings, the data are divided into those accidents that occurred in Vietnam, those accidents that occurred elsewhere, and their combined total. Since the vast majority of the accidents that do not occur in Vietnam (VN) take place within the continental limits of the United States, the abbreviation US is arbitrarily used to denote all accidents which do not occur in Vietnam. It should be realized then that the US data grouping will include a small number of accidents which may have occurred, for example, in Europe, Africa, or elsewhere. A second point to be stressed is that the VN data pertain strictly to accidents, not losses due to enemy action.

In the interpretation of the accident statistics to follow, it becomes possible to compare FW and RW accident incidence or VN and US accident incidence only when some common measures of aircraft utilization are selected as weighting factors. To establish such comparative references, percent aircraft inventory, total flying hours, and total aircraft landings are used as basic weighting data in this report. These data, as well as the incidence and cost statistics presented in this section, are summarized in Tables I through IV. Table I pertains to all accidents in all types of aircraft, Table II to only FW accidents, and Table III to only RW accidents. The ratio of the RW data in Table III to the FW data in Table II is summarized in Table IV.

The aircraft inventory data listed in the fourth row of each of the tables indicate the following: First, as shown by Table I, more aircraft operated out of US than out of VN. In relative terms 65.6 percent of the total FW and RW aircraft inventory were stationed in US as compared to only 34.4 percent in VN. The second point, derived from Tables II and III, is that RW aircraft remain the predominant aircraft in the aircraft inventory. Of the total number of aircraft, 82.7 percent were of the RW type and 17.3 percent of the FW type. For both types of aircraft, the VN/US inventory ratio was less than unity; i.e., 0.36 to 1 for FW and 0.56 to 1 for RW. Accordingly, in terms of average aircraft inventory, the majority of the aircraft operated in US and the majority of the aircraft were of the RW type. This is in correspondence with the inventory data of fiscal years 1967-1970.

TABLE I				
FISCAL YEAR 1971 DATA				
ALL ACCIDENT TYPES		ALL AIRCRAFT		
ACCIDENT INDEX	U.S. ACCIDENTS	VIETNAM ACCIDENTS	ALL ACCIDENTS	VN to US RATIO
Major Accidents	193	486	679	2.52
Minor Accidents	18	11	29	0.61
Total Accidents	211	497	708	2.36
Aircraft Inventory - Percent Total	65.59	34.42	100.00	0.53
Total Flying Hours	2,293,349	2,642,512	4,935,861	1.15
Total Landings	7,433,991	6,963,454	14,397,445	0.94
Major Accidents per 100,000 Hours	8.42	18.39	13.76	2.19
Minor Accidents per 100,000 Hours	0.79	0.42	0.59	0.53
Total Accidents per 100,000 Hours	9.20	18.81	14.35	2.05
Major Accidents per 100,000 Landings	2.60	6.98	4.72	2.69
Minor Accidents per 100,000 Landings	0.24	0.16	0.20	0.65
Total Accidents per 100,000 Landings	2.84	7.14	4.92	2.52
Total Dollar Cost	19,480,638	98,075,391	117,556,029	5.04
Average Dollar Cost per Accident	92,325.30	197,334.79	166,039.59	2.14
Total Fatalities	63	261	324	4.14
Average Fatalities per Accident	0.30	0.53	0.46	1.76
Fatal Accidents - Number	30	89	119	2.97
Fatal Accidents - Percent	14.22	17.91	16.81	1.26
Average Fatalities per Fatal Accident	2.10	2.93	2.72	1.40
Total Nonfatal Injuries	105	542	647	5.16
Average Nonfatal Injuries per Accident	0.50	1.09	0.91	2.19

TABLE II				
FISCAL YEAR 1971 DATA				
ALL ACCIDENT TYPES		FIXED WING AIRCRAFT ONLY		
ACCIDENT INDEX	U.S. ACCIDENTS	VIETNAM ACCIDENTS	ALL ACCIDENTS	VN to US RATIO
Major Accidents	51	27	78	0.53
Minor Accidents	9	0	9	---
Total Accidents	60	27	87	0.45
Aircraft Inventory - Percent Total	12.67	4.60	17.27	0.36
Total Flying Hours	494,659	323,601	818,260	0.66
Total Landings	893,446	300,913	1,194,359	0.34
Major Accidents per 100,000 Hours	10.31	8.23	9.53	0.81
Minor Accidents per 100,000 Hours	1.82	0.00	1.10	0.00
Total Accidents per 100,000 Hours	12.13	8.34	10.63	0.69
Major Accidents per 100,000 Landings	5.71	8.97	6.53	1.57
Minor Accidents per 100,000 Landings	1.01	0.00	0.75	0.00
Total Accidents per 100,000 Landings	6.72	8.97	7.29	1.34
Total Dollar Cost	5,600,839	7,073,313	12,674,152	1.26
Average Dollar Cost per Accident	93,347.32	261,974.56	145,679.91	2.81
Total Fatalities	25	12	37	0.48
Average Fatalities per Accident	0.42	0.45	0.43	1.07
Fatal Accidents - Number	11	6	17	0.55
Fatal Accidents - Percent	18.33	22.22	19.54	1.21
Average Fatalities per Fatal Accident	2.27	2.00	2.18	0.88
Total Nonfatal Injuries	19	9	28	0.47
Average Nonfatal Injuries per Accident	0.32	0.33	0.32	1.05

TABLE III				
FISCAL YEAR 1971 DATA				
ALL ACCIDENT TYPES		ROTARY WING AIRCRAFT ONLY		
ACCIDENT INDEX	U.S. ACCIDENTS	VIETNAM ACCIDENTS	ALL ACCIDENTS	VN to US RATIO
Major Accidents	142	459	601	3.23
Minor Accidents	9	11	20	1.22
Total Accidents	151	470	621	3.11
Aircraft Inventory - Percent Total	52.91	29.82	82.73	0.56
Total Flying Hours	1,798,690	2,318,911	4,117,601	1.29
Total Landings	6,540,545	6,662,541	13,203,086	1.02
Major Accidents per 100,000 Hours	7.90	19.79	14.60	2.51
Minor Accidents per 100,000 Hours	0.50	0.48	0.49	0.95
Total Accidents per 100,000 Hours	8.40	20.27	15.08	2.42
Major Accidents per 100,000 Landings	2.17	6.89	4.55	3.17
Minor Accidents per 100,000 Landings	0.14	0.17	0.15	1.20
Total Accidents per 100,000 Landings	2.31	7.06	4.70	3.06
Total Dollar Cost	13,879,799	91,002,078	104,881,877	6.56
Average Dollar Cost per Accident	91,919.20	193,621.44	168,891.91	2.11
Total Fatalities	38	249	287	6.55
Average Fatalities per Accident	0.25	0.53	0.46	2.11
Fatal Accidents - Number	19	83	102	4.37
Fatal Accidents - Percent	12.58	17.66	16.43	1.40
Average Fatalities per Fatal Accident	2.00	3.00	2.81	1.50
Total Nonfatal Injuries	86	533	619	6.20
Average Nonfatal Injuries per Accident	0.57	1.14	1.00	1.99

TABLE IV			
FISCAL YEAR 1971 DATA			
ALL ACCIDENT TYPES		RATIO OF RW TO FW DATA	
ACCIDENT INDEX	U.S. ACCIDENTS	VIETNAM ACCIDENTS	ALL ACCIDENTS
Major Accidents	2.79	17.00	7.71
Minor Accidents	1.00	---	2.22
Total Accidents	2.52	17.41	7.14
Aircraft Inventory - Percent Total	4.18	6.48	4.79
Total Flying Hours	3.64	7.17	5.03
Total Landings	7.32	22.14	11.06
Major Accidents per 100,000 Hours	0.77	2.37	1.53
Minor Accidents per 100,000 Hours	0.28	0.00	0.44
Total Accidents per 100,000 Hours	0.69	2.43	1.42
Major Accidents per 100,000 Landings	0.38	0.77	0.70
Minor Accidents per 100,000 Landings	0.14	0.00	0.20
Total Accidents per 100,000 Landings	0.34	0.79	0.65
Total Dollar Cost	2.48	12.87	8.28
Average Dollar Cost per Accident	0.99	0.74	1.16
Total Fatalities	1.52	20.75	7.76
Average Fatalities per Accident	0.60	1.19	1.09
Fatal Accidents - Number	1.73	13.83	6.00
Fatal Accidents - Percent	0.69	0.80	0.84
Average Fatalities per Fatal Accident	0.88	1.50	1.29
Total Nonfatal Injuries	4.53	59.22	22.11
Average Nonfatal Injuries per Accident	1.80	3.40	3.10

The total aircraft flight hours data to be used as an accident weighting factor are plotted in Figure 1A for both aircraft types and for both geographical references. The visual interpretation of this graph, as well as the majority of the remaining graphs in the report, is as follows: The group of three bars drawn at the left in Figure 1A pertain to the total flying hours of all FW aircraft. Within this three-bar group, the right-hand bar, marked VN, plots the total number of FW hours flown in Vietnam; the left-hand bar, marked US, plots the total number of hours flown elsewhere (primarily in the United States); and the central bar of this group, marked ALL, is a plot of the direct sum of the adjacent VN and US data. The interpretation of the three-bar group drawn at the right in Figure 1A follows identically except that total hours of RW aircraft are involved. Similarly, the three-bar group at the center of the figure describes the total hours of both types of aircraft with the depicted data representing the direct sum of the adjacent FW and RW data.

The data of Figure 1A and Table I show that for fiscal year 1971, 2,642,512 hours were flown in VN as compared to 2,293,349 hours flown elsewhere. As indicated by the RW/FW ratio data presented in Table IV, flight hours in RW aircraft were 5.03 times as great as FW hours. Corresponding weighting data based on aircraft landings are plotted in Figure 1B. As would be expected, the total number of RW landings far exceeds those of the FW aircraft even allowing for the difference in inventory. Related weighting-factor data, with total aircraft landings serving as reference, are plotted in Figure 1B.

With these aircraft utilization data serving as reference, it becomes possible to make a weighted interpretation of the raw accident data presented in Tables I through IV. The numerical incidence of all major and minor accidents, regardless of type or causal factor, is plotted in Figure 2. The cost of these accidents, as measured by the total number of fatal accidents, number of fatalities, number of nonfatal injuries, and aircraft dollar damage is outlined in Figures 3A through 3D, respectively.

In terms of the over-all aircraft accident problem, these data show that during fiscal year 1971, there were a total of 708 accidents, 119 of which were fatal; there resulted 324 fatalities, 647 nonfatal injuries, and a total aircraft damage cost of \$117,556,029. The FW aircraft contribution to these totals was 87 accidents (17 of which were fatal), resulting in 37 fatalities, 28 nonfatal injuries, and a total aircraft damage cost of \$12,674,152. The RW data show 621 accidents (102 of which were fatal), resulting in 287 fatalities, 619 nonfatal injuries, and a total aircraft damage cost of \$104,881,877. For FW aircraft, accident incidence in VN was 0.45 times the US incidence. For RW aircraft, accident incidence in VN was 3.11 times the US incidence.

The Table I data show also that the cost of these VN accidents was considerable in terms of personnel and aircraft. That is, there were 2.97 times as many fatal accidents in VN as there were elsewhere, 4.14 times as many fatalities, and 5.16 times as many nonfatal injuries. In addition, the average dollar cost of a VN accident was 2.14 times the cost of a US accident. In terms of total dollar damage to the accident aircraft, the VN cost was 5.04 times the US cost. These fiscal year 1971 findings support

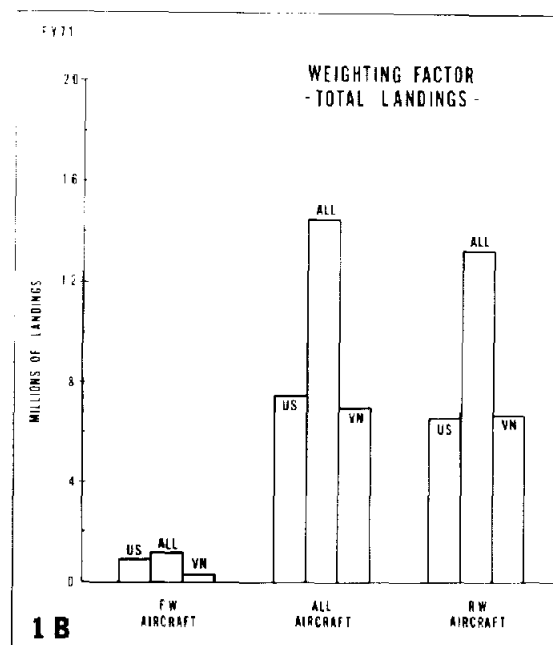
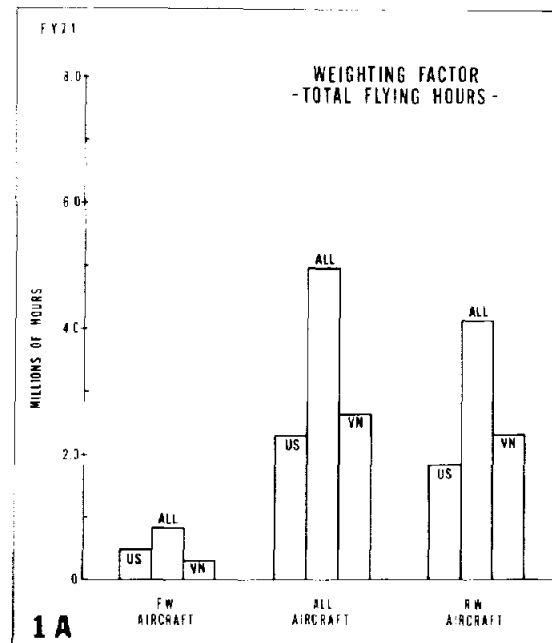


Figure 1

Total flying hours (A) and total landings (B) by aircraft type and location during fiscal year 1971. In A, the three bars at the left pertain to fixed wing (FW) aircraft with the VN bar indicating total FW hours flown in Vietnam; the US bar total hours flown elsewhere (primarily in the United States); and the ALL bar the sum of the adjacent VN/US data. The layout of the three bars at the extreme right is identical, but pertains to rotary wing (RW) aircraft hours. The three central bars summarize the FW and RW data and represent total hours of all aircraft types. Total RW hours were 5.03 times the total FW hours while total RW landings were 11.06 times the total FW landings.

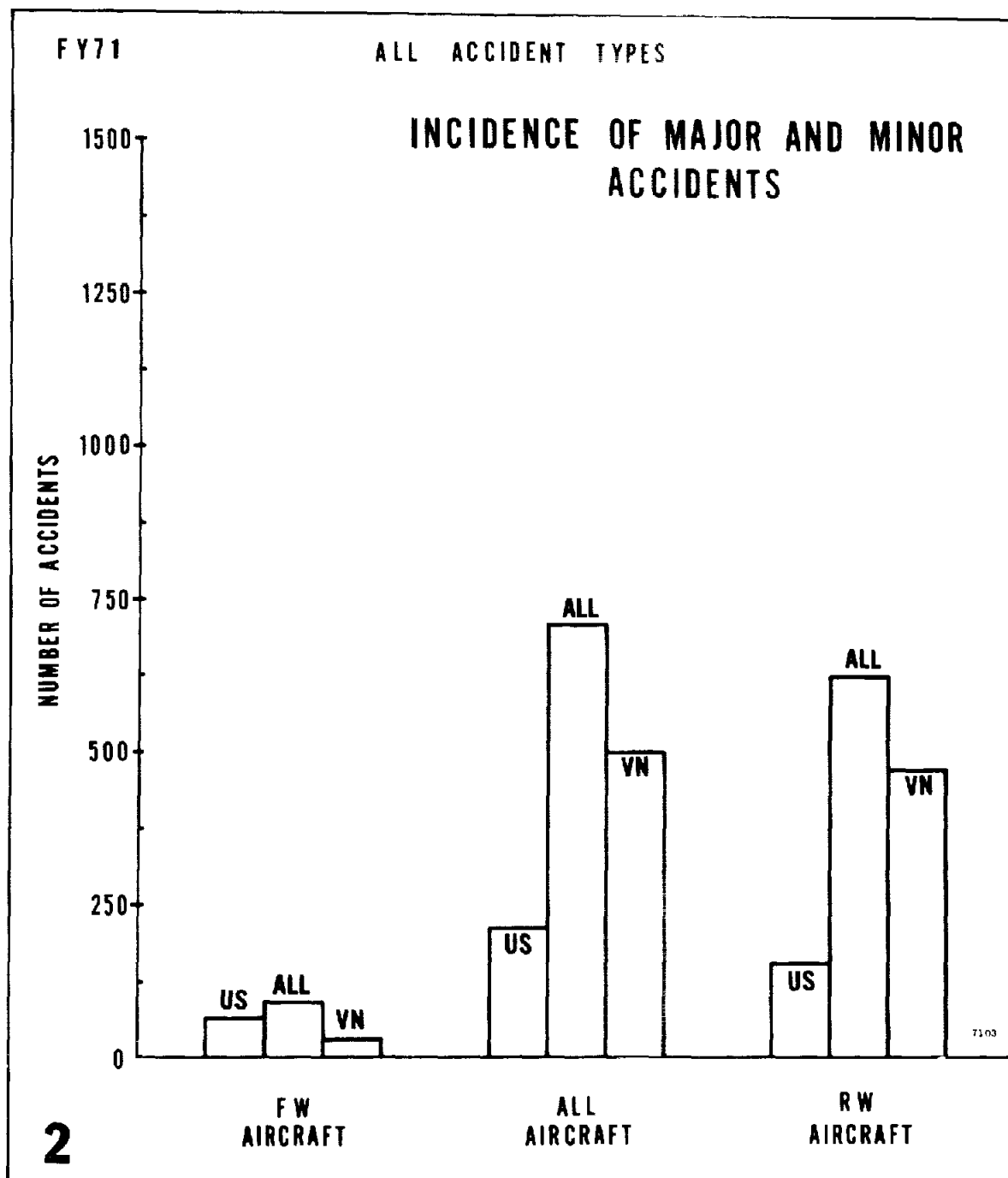


Figure 2

All Accident Types: Total number of major and minor aircraft accidents of all types that occurred in Regular Army flight operations during fiscal year 1971. Total number of FW accidents is shown by the center bar at the left, with the adjacent VN and US bars indicating location of the accidents. Data for RW accidents are at the extreme right, with total accidents of both aircraft types summarized in the center. The VN data presented throughout this report pertain to aircraft accidents, not losses due to enemy action, that occurred in Vietnam. Considering all aircraft, the incidence of accidents in VN was 2.36 times greater than the incidence elsewhere.

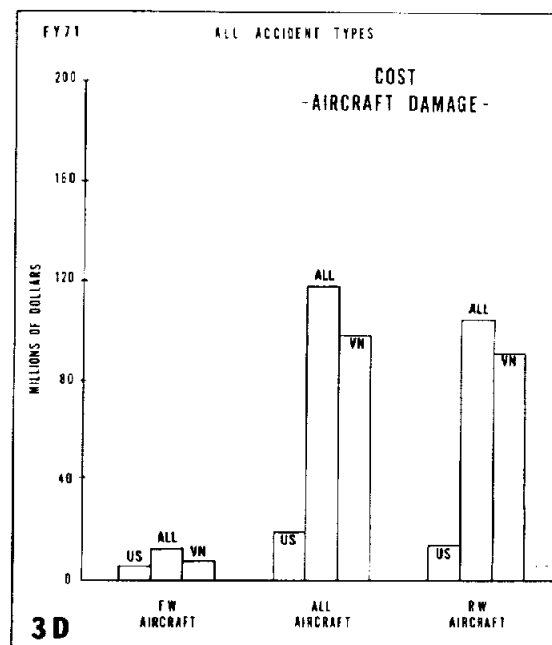
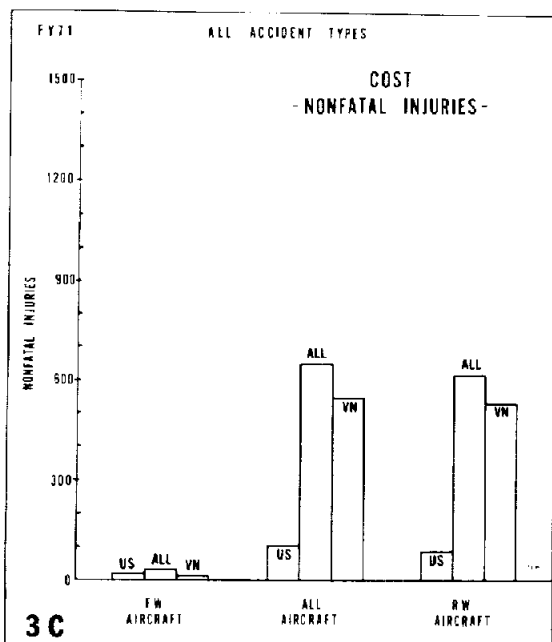
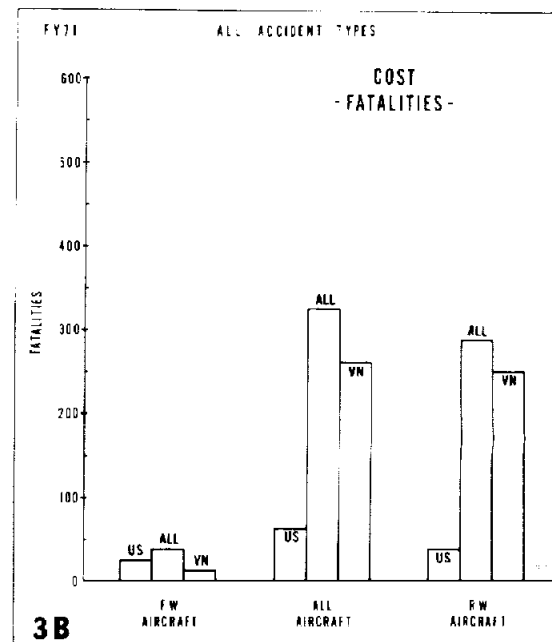
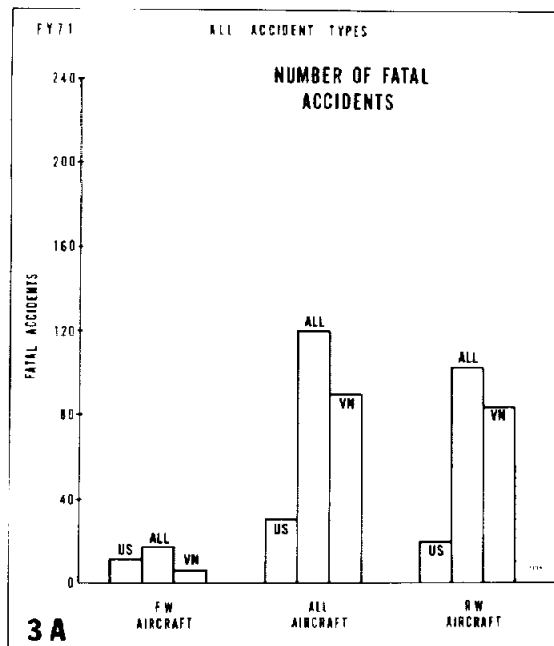


Figure 3

All Accident Types: Total number of fatal accidents (A), total number of fatalities (B), total number of nonfatal injuries (C), and total dollar cost of resulting aircraft damage (D) for both RW and FW aircraft and for both VN and US locations. For RW aircraft, the loss was always greatest in VN.

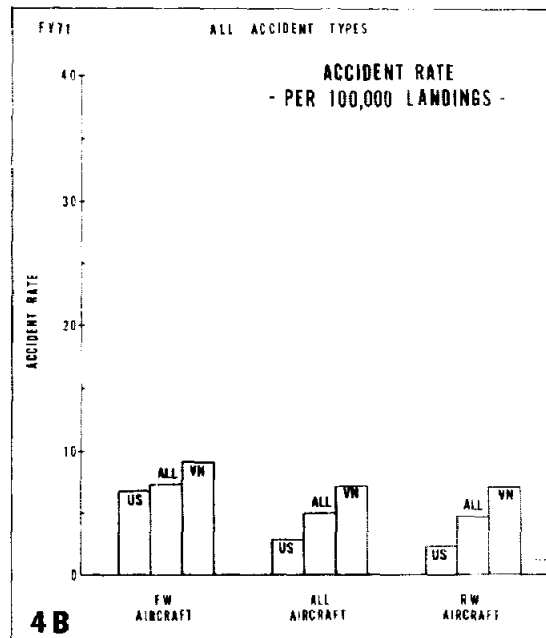
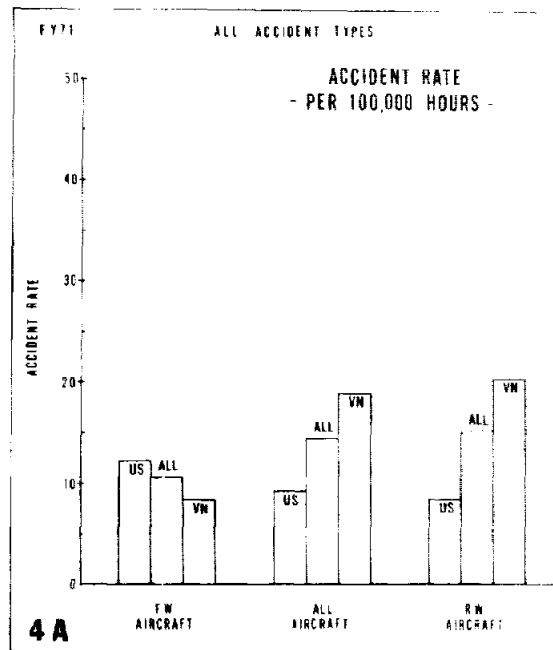


Figure 4

All Accident Types: Normalized incidence data showing average number of accidents per 100,000 flying hours (A) and average number of accidents per 100,000 landings (B). For all FW aircraft, the rates were 10.63 and 7.29 accidents per 100,000 hours and per 100,000 landings, respectively. For all RW aircraft, the rates were 15.08 and 4.70 accidents per 100,000 hours and per 100,000 landings, respectively.

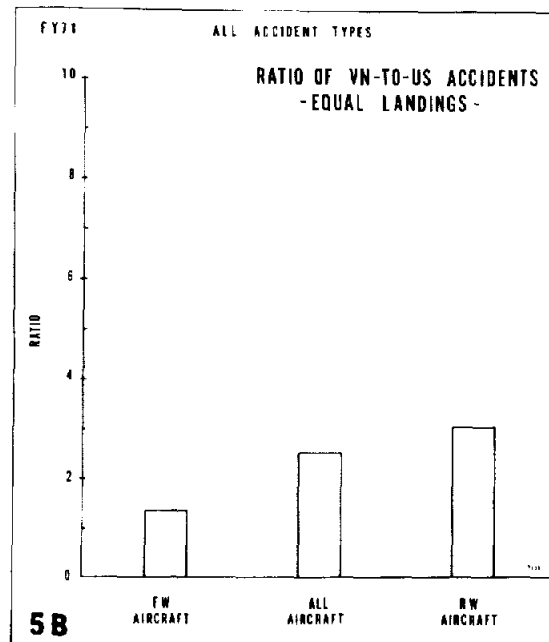
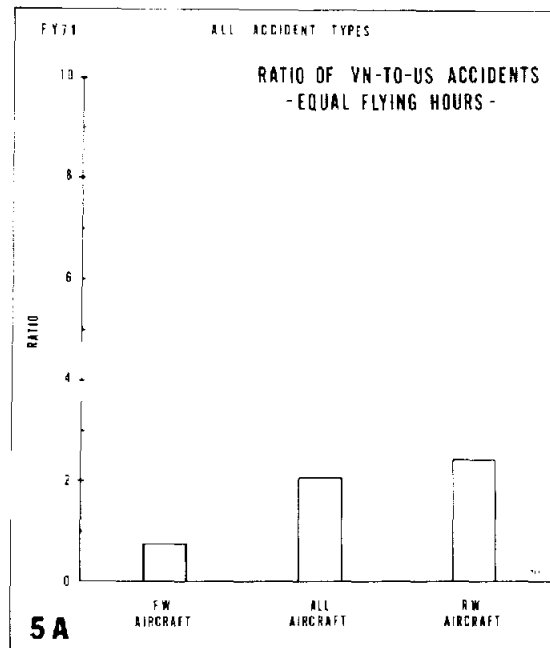


Figure 5

All Accident Types: Normalized ratio of accidents occurring in VN to accidents occurring in US based on equal flying hours (A) and equal landings (B) for both types of aircraft. Based on equal hours, the accident rates in VN for FW and RW aircraft were 0.69 and 2.42 times as great, respectively, as the US rates. Based on equal landings, the accident rates in VN for FW and RW aircraft were 1.34 and 3.06 times as great, respectively, as the US rates.

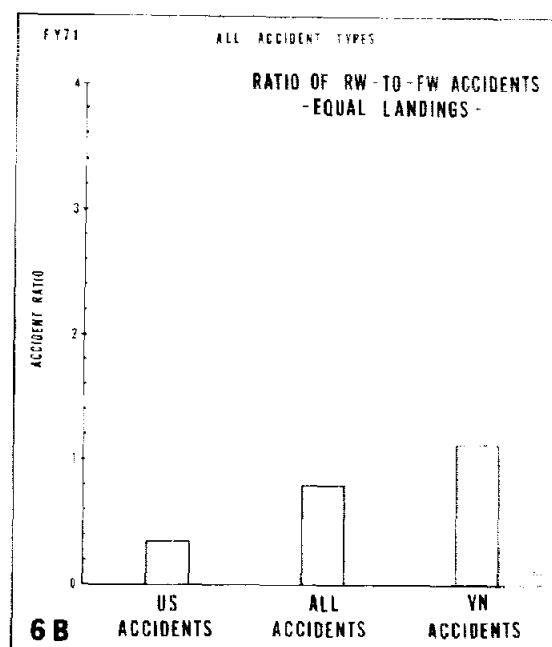
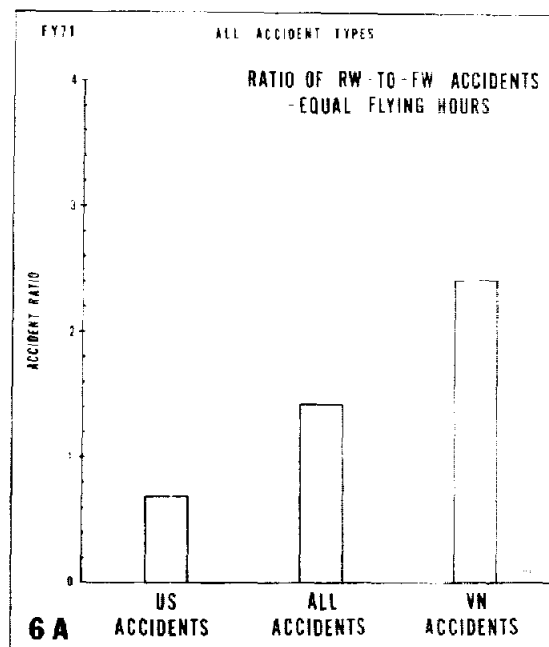


Figure 6

All Accident Types: Normalized ratio of accidents occurring in RW aircraft to accidents occurring in FW aircraft based on equal flying hours (A) and equal landings (B) for both locations.

the fiscal years 1967-1970 data with regards to establishing the significantly greater accident incidence and accident costs associated with the stresses of a combat-oriented environment.

To facilitate the comparison of these fiscal year 1971 data with accident incidence data presented for previous years of the study, the data sets in Figure 2 have been normalized relative to the total number of flying hours flown by each type of aircraft in both locales and plotted in Figure 4A as the average number of accidents occurring every 100,000 hours. The same normalization with total landings as reference was accomplished for Figure 4B which shows the accident rate for every 100,000 landings. The VN/US ratio of these rate data for both aircraft types are plotted in Figure 5. Considering only FW aircraft, the VN accident rate decreased relative to the US rate (0.69 to 1) when total hours served as reference. When total landings are considered, the FW accident rate in VN was 1.34 times greater than the US rate. For RW aircraft, the VN accident rate was considerably greater than the US rate for either weighting reference; i.e., the VN accident rate based on hours was 2.42 times the US rate and 3.06 times as great based on landings. As with the fiscal years 1967-1970 rate data, the cost of the combat-oriented VN environment in terms of accident incidence was greatest for RW aircraft.

To show the relationship between accident incidence in RW aircraft and that in FW aircraft, the ratio of the RW to FW accident rate data presented in Figure 5 is plotted for the two locations in Figure 6. These data are also listed in Table IV. The RW/FW accident ratio for US operations, based on equal hours, was 0.69 to 1 indicating that the probability of an accident was less for RW aircraft. The same ratio for VN operations was 2.43 to 1 indicating a greater risk in RW aircraft. When landings are used as reference, however, the RW/FW accident ratio drops to 0.34 to 1 for US operations and 0.79 to 1 for VN operations indicating a greater risk in FW aircraft.

PILOR-ERROR ACCIDENTS

In this section, incidence and cost data are presented for all accidents that were classified by USAAVS as involving one or more pilot-error causal factors. It should be observed that this classification does not imply that pilot error was the only, or even the primary, accident causal factor. That is, this grouping includes all accidents involving one or more pilot errors even though, for example, materiel failure, maintenance shortcomings, or poor facilities may also have contributed to the cause of the accident. A further point, by definition, is that these pilot-error accidents are a subgroup of the all-accident statistics discussed in the previous section.

Incidence and cost data for these fiscal year 1971 pilot-error accidents are presented in Tables V through VIII, with the Table V data pertaining to accidents in all types of aircraft, the Table VI data to only FW accidents, the Table VII data to only RW accidents, and the Table VIII data describing the ratio of the RW to FW data presented in Tables VII and VI, respectively. Selected incidence and cost data are depicted in Figures 7 and 8. Normalized accident rate data, based on the total hours and

TABLE V FISCAL YEAR 1971 DATA				
PILOT-ERROR ACCIDENTS ONLY		ALL AIRCRAFT		
ACCIDENT INDEX	U.S. ACCIDENTS	VIETNAM ACCIDENTS	ALL ACCIDENTS	VN to US RATIO
Major Accidents	148	294	442	1.99
Minor Accidents	14	8	22	0.57
Total Accidents	162	302	464	1.87
Total Dollar Cost	11,855,979	54,245,663	66,101,642	4.58
Average Dollar Cost per Accident	73,185.06	179,621.40	142,460.44	2.46
Total Fatalities	43	149	192	3.47
Average Fatalities per Accident	0.27	0.49	0.41	1.86
Fatal Accidents - Number	21	55	76	2.62
Fatal Accidents - Percent	12.96	18.21	16.38	1.41
Average Fatalities per Fatal Accident	2.05	2.71	2.53	1.32
Total Nonfatal Injuries	82	341	423	4.16
Average Nonfatal Injuries per Accident	0.51	1.13	0.91	2.23

TABLE VI FISCAL YEAR 1971 DATA				
PILOT-ERROR ACCIDENTS ONLY		FIXED WING AIRCRAFT		
ACCIDENT INDEX	U.S. ACCIDENTS	VIETNAM ACCIDENTS	ALL ACCIDENTS	VN to US RATIO
Major Accidents	37	19	56.00	0.51
Minor Accidents	5	0	5.00	---
Total Accidents	42	19	61.00	0.45
Total Dollar Cost	3,656,352	2,603,950	6,260,302	0.71
Average Dollar Cost per Accident	87,056.00	137,050.00	102,627.90	1.58
Total Fatalities	15	5	20	0.33
Average Fatalities per Accident	0.36	0.26	0.33	0.74
Fatal Accidents - Number	7	3	10	0.43
Fatal Accidents - Percent	16.67	15.79	16.39	0.95
Average Fatalities per Fatal Accident	2.14	1.67	2.00	0.78
Total Nonfatal Injuries	14	8	22	0.57
Average Nonfatal Injuries per Accident	0.33	0.42	0.36	1.26

TABLE VII FISCAL YEAR 1971 DATA				
PILOT-ERROR ACCIDENTS ONLY		ROTARY WING AIRCRAFT		
ACCIDENT INDEX	U.S. ACCIDENTS	VIETNAM ACCIDENTS	ALL ACCIDENTS	VN to US RATIO
Major Accidents	111	275	386	2.48
Minor Accidents	9	8	17	0.89
Total Accidents	120	283	403	2.36
Total Dollar Cost	8,199,627	51,641,713	59,841,340	6.30
Average Dollar Cost per Accident	68,330.23	182,479.55	148,489.68	2.67
Total Fatalities	28	144	172	5.14
Average Fatalities per Accident	0.23	0.51	0.43	2.18
Fatal Accidents - Number	14	52	66	3.72
Fatal Accidents - Percent	11.67	18.38	16.38	1.58
Average Fatalities per Fatal Accident	2.00	2.77	2.61	1.39
Total Nonfatal Injuries	68	333	401	4.90
Average Nonfatal Injuries per Accident	0.57	1.18	1.00	2.08

TABLE VIII FISCAL YEAR 1971 DATA			
PILOT-ERROR ACCIDENTS ONLY		RATIO OF RW TO FW DATA	
ACCIDENT INDEX	U.S. ACCIDENTS	VIETNAM ACCIDENTS	ALL ACCIDENTS
Major Accidents	3.00	14.47	6.89
Minor Accidents	1.80	---	3.40
Total Accidents	2.86	14.90	6.61
Total Dollar Cost	2.24	19.83	9.56
Average Dollar Cost per Accident	0.79	1.33	1.45
Total Fatalities	1.87	28.80	8.60
Average Fatalities per Accident	0.65	1.93	1.30
Fatal Accidents - Number	2.00	17.33	6.60
Fatal Accidents - Percent	0.70	1.16	1.00
Average Fatalities per Fatal Accident	0.93	1.66	1.30
Total Nonfatal Injuries	4.86	41.63	18.23
Average Nonfatal Injuries per Accident	1.70	2.80	2.76

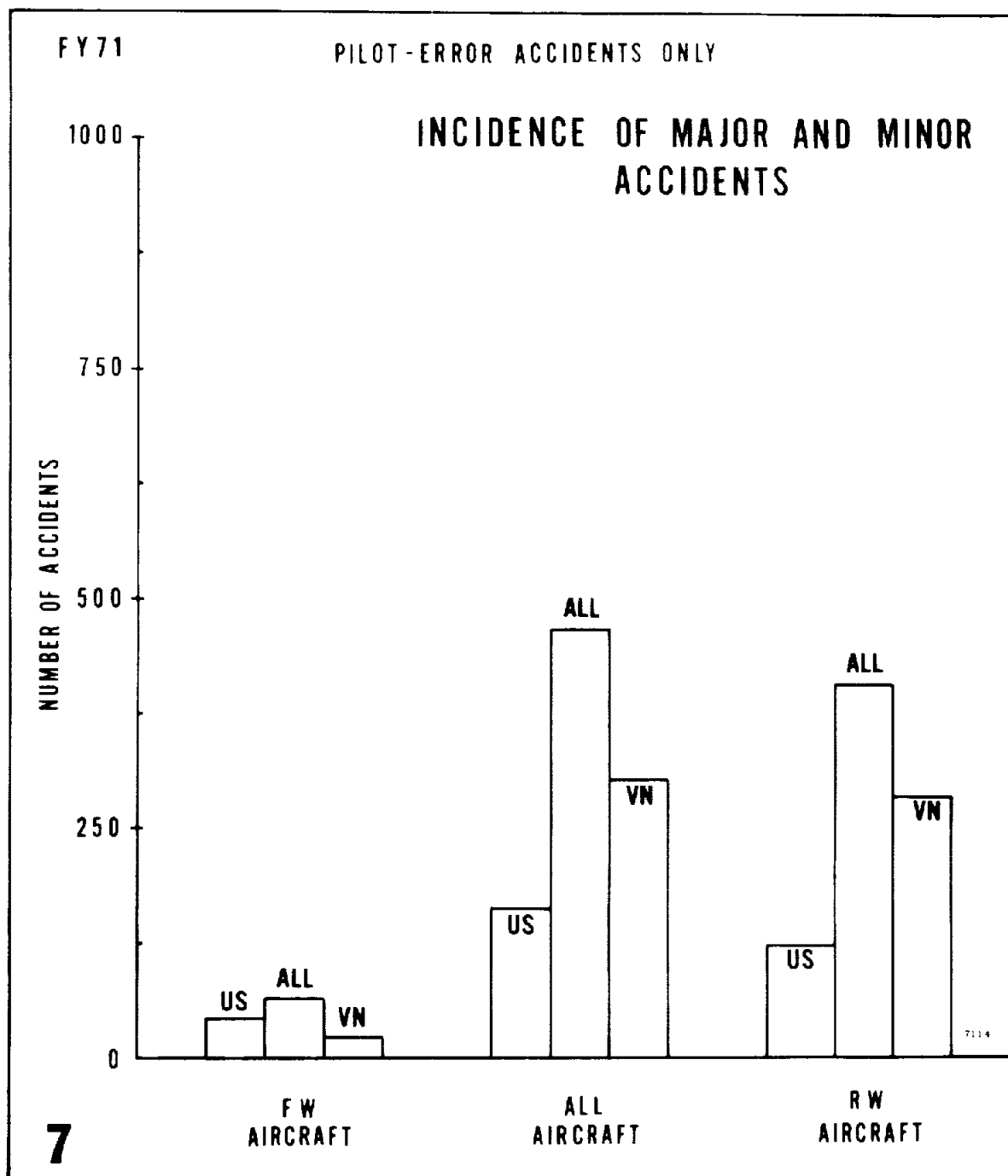


Figure 7

Pilot-Error Accident Types: Total number of major and minor accidents that were classified by USAAVS as involving one or more pilot-error factors. As with the Figure 2 "All Accident Type" incidence data, the number of pilot-error accidents occurring in RW aircraft operating out of VN considerably exceeded those occurring elsewhere. However, for FW aircraft, the number of pilot-error accidents that occurred in VN was slightly less than the US total. Considering all aircraft, the VN incidence was 1.87 times greater than the US incidence.

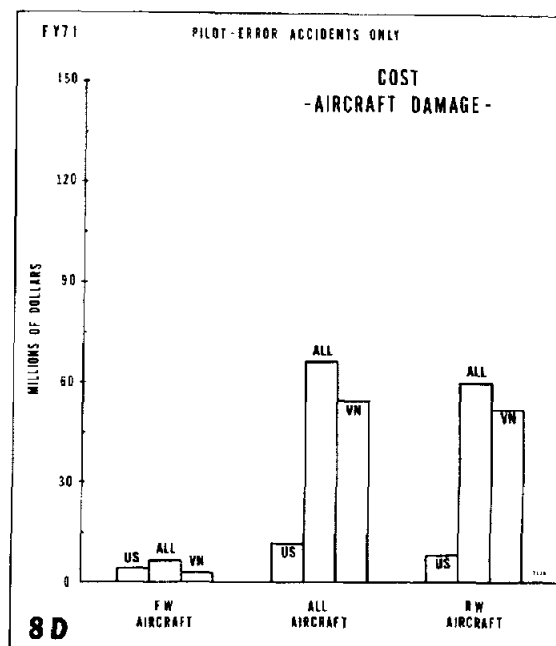
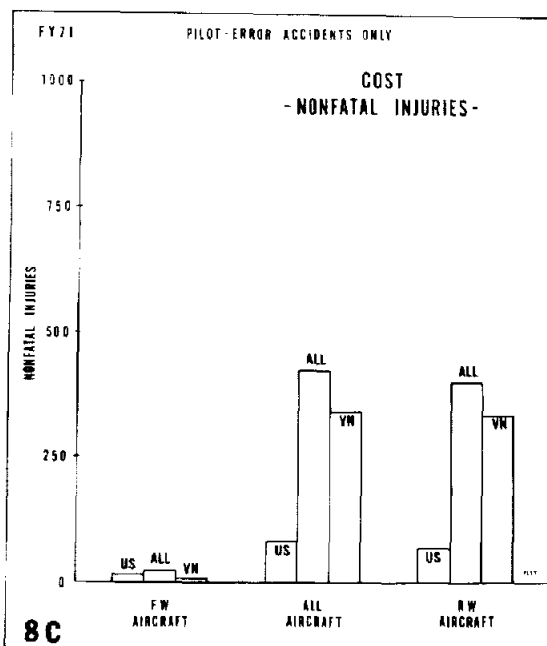
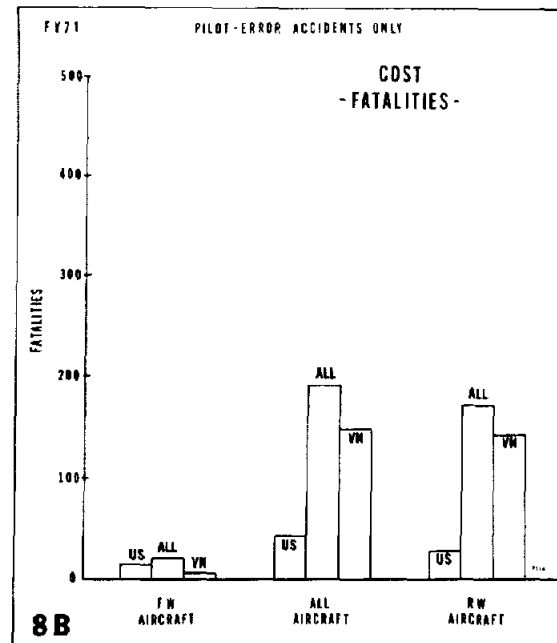
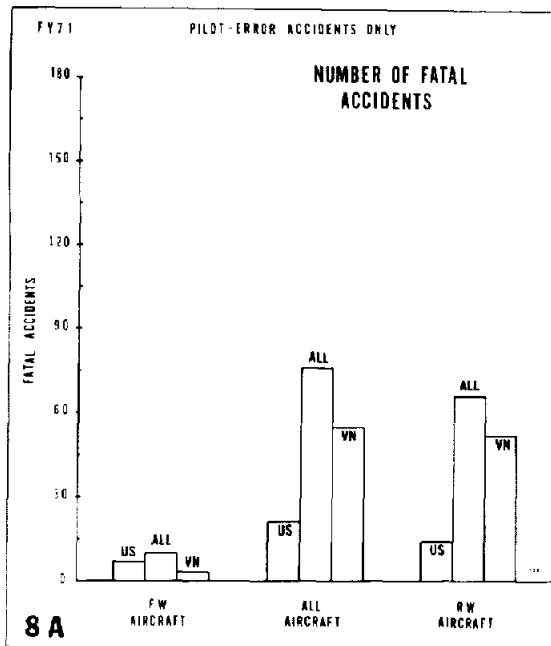


Figure 8

Pilot-Error Accident Types: Total number of fatal accidents (A), total number of fatalities (B), total number of nonfatal injuries (C), and total dollar cost of resulting aircraft damage (D) for both aircraft types and for both locations. For RW aircraft, the loss was always much greater in VN.

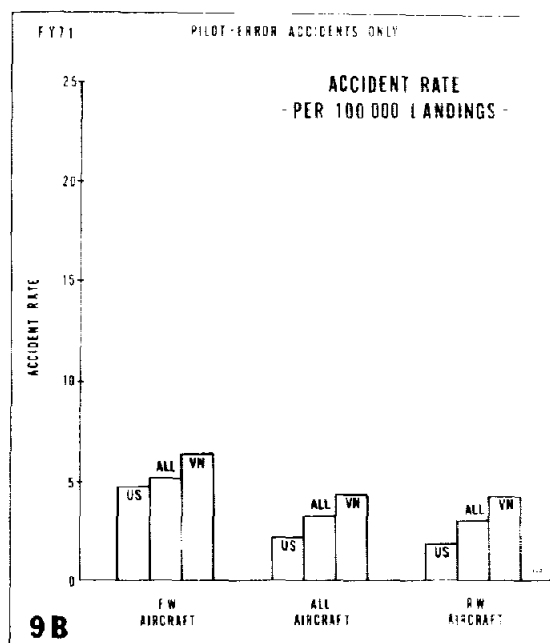
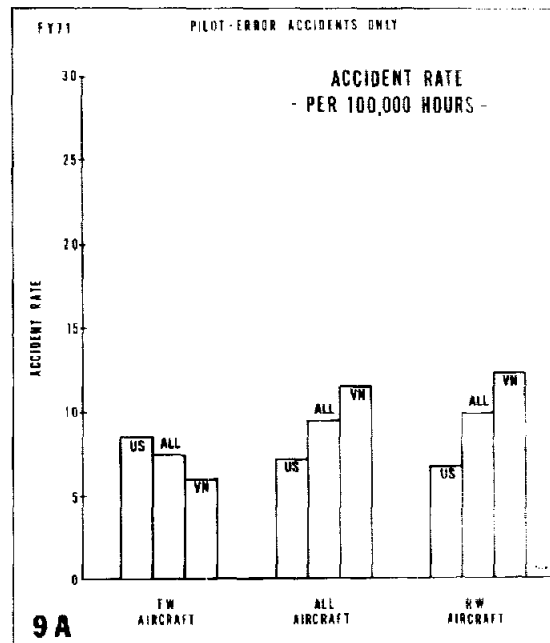


Figure 9

Pilot-Error Accident Types: Normalized incidence data showing average number of pilot-error accidents per 100,000 flying hours (A) and average number of pilot-error accidents per 100,000 landings (B). These rate data are intended only as a fiscal year 1971 baseline reference for comparison with similar data calculated for other fiscal years of the longitudinal study. For FW aircraft, the over-all rates were 7.46 and 5.11 accidents per 100,000 hours and per 100,000 landings, respectively. For RW aircraft, the over-all rates were 9.79 and 3.05 accidents per 100,000 hours and per 100,000 landings, respectively.

total landings data of Figure 1, are plotted in Figure 9. These rate data, as with the rate data of Figure 4, are intended primarily as a baseline reference for comparison with similar data presented for other fiscal years of the study.

The incidence data of Figure 7 show that there was a total of 464 major and minor accidents involving pilot error; of this total, 76 were fatal accidents. The over-all cost was 192 fatalities, 423 nonfatal injuries, and \$66,101,642 aircraft damage. The FW contribution to this total was 61 accidents (10 of which were fatal), resulting in 20 fatalities, 22 nonfatal injuries, and \$6,260,302 aircraft damage. For RW aircraft, there were 403 accidents (66 of which were fatal), resulting in 172 fatalities, 401 nonfatal injuries, and \$59,841,340 aircraft damage. The incidence of pilot-error accidents was 2.36 times as great in VN as in the US for RW aircraft. For FW aircraft, however, the incidence in VN was less (0.45 to 1) than that in the US.

As with the all-accident data, the cost of RW pilot-error accidents in terms of personnel and aircraft damage was greatest in VN. As calculated in Table VII and depicted in Figure 8, there were 3.72 times as many fatal RW accidents in VN as there were elsewhere, 5.14 times as many fatalities, and 4.90 times as many nonfatal injuries. In addition, the average dollar cost of a RW pilot-error accident in VN was 2.67 times the US average. In terms of total RW aircraft damage, the VN cost was 6.30 times the US cost. For the FW pilot-error accidents, the corresponding VN/US cost ratios were less than unity indicating a greater loss in US.

The RW accident rate data presented in Figure 9 also establishes the higher cost of VN operations for this type aircraft. The over-all RW rates were 9.79 and 3.05 accidents per 100,000 hours and per 100,000 landings, respectively. The VN rate was 1.83 times the US rate based on hours and 2.32 times the US rate based on landings. For FW aircraft, the over-all accident rates were 7.46 and 5.11 accidents per 100,000 hours and per 100,000 landings, respectively. The VN rate was 0.69 times the US rate based on equal hours and 1.34 times the US rate based on equal landings.

ORIENTATION-ERROR ACCIDENTS ONLY

This section summarizes the incidence and cost of all orientation-error type accidents detected in our review of the USAAVS accident files. As detailed with selected qualifications in the procedure section of this report, this listing includes all accidents arising from an incorrect control or power action taken by a pilot due to his incorrect perception of the true motion or attitude of his aircraft. The reader should recognize that the orientation-error accidents discussed herein are a subgroup of the pilot-error accident statistics presented in the previous section.

The main elements of the orientation-error statistics are summarized in Tables IX through XII, with the Table IX data pertaining to accidents in all types of aircraft, the Table X data to only FW accidents, the Table XI data to only RW accidents, and the Table XII data describing the ratio of the RW to FW data presented in Tables XI and X, respectively. The pertinent incidence and cost data are outlined in Figures 10 and 11.

TABLE IX FISCAL YEAR 1971 DATA ORIENTATION-ERROR ACCIDENTS ONLY				
ACCIDENT INDEX	U.S. ACCIDENTS	VIETNAM ACCIDENTS	ALL ACCIDENTS	VN to US RATIO
Major Accidents	12	38	50	3.17
Minor Accidents	0	0	0	---
Total Accidents	12	38	50	3.17
Total Dollar Cost	1,344,217	10,059,902	11,404,119	7.48
Average Dollar Cost per Accident	112,018.08	264,734.26	228,082.38	2.36
Total Fatalities	11	54	65	4.91
Average Fatalities per Accident	0.92	1.42	1.30	1.55
Fatal Accidents - Number	5	20	25	4.00
Fatal Accidents - Percent	41.67	52.63	50.00	1.26
Average Fatalities per Fatal Accident	2.20	2.70	2.60	1.23
Total Nonfatal Injuries	14	53	67	3.79
Average Nonfatal Injuries per Accident	1.17	1.40	1.34	1.20

TABLE X FISCAL YEAR 1971 DATA ORIENTATION-ERROR ACCIDENTS ONLY				
ACCIDENT INDEX	U.S. ACCIDENTS	VIETNAM ACCIDENTS	ALL ACCIDENTS	VN to US RATIO
Major Accidents	2	1	3	0.50
Minor Accidents	0	0	0	---
Total Accidents	2	1	3	0.50
Total Dollar Cost	199,058	13,684	212,742	0.07
Average Dollar Cost per Accident	99,529.00	13,684.00	70,914.00	0.14
Total Fatalities	3	0	3	---
Average Fatalities per Accident	1.50	0.00	1.00	---
Fatal Accidents - Number	2	0	2	---
Fatal Accidents - Percent	100.00	0.00	66.67	---
Average Fatalities per Fatal Accident	1.50	---	1.50	---
Total Nonfatal Injuries	0	0	0	---
Average Nonfatal Injuries per Accident	0.00	0.00	0.00	---

TABLE XI FISCAL YEAR 1971 DATA ORIENTATION-ERROR ACCIDENTS ONLY ROTARY WING AIRCRAFT				
ACCIDENT INDEX	U.S. ACCIDENTS	VIETNAM ACCIDENTS	ALL ACCIDENTS	VN to US RATIO
Major Accidents	10	37	47	3.70
Minor Accidents	0	0	0	---
Total Accidents	10	37	47	3.70
Total Dollar Cost	1,145,159	10,046,218	11,191,377	8.77
Average Dollar Cost per Accident	114,515.90	271,519.41	238,114.41	2.37
Total Fatalities	8	54	62	6.75
Average Fatalities per Accident	0.80	1.46	1.32	1.83
Fatal Accidents - Number	3	20	23	6.67
Fatal Accidents - Percent	30.00	54.06	48.94	1.80
Average Fatalities per Fatal Accident	2.67	2.70	2.70	1.01
Total Nonfatal Injuries	14	53	67	3.79
Average Nonfatal Injuries per Accident	1.40	1.43	1.43	1.02

TABLE XII FISCAL YEAR 1971 DATA ORIENTATION-ERROR ACCIDENTS ONLY RATIO OF RW TO FW DATA			
ACCIDENT INDEX	U.S. ACCIDENTS	VIETNAM ACCIDENTS	ALL ACCIDENTS
Major Accidents	5.00	37.00	15.67
Minor Accidents	---	---	---
Total Accidents	5.00	37.00	15.67
Total Dollar Cost	5.75	734.16	52.61
Average Dollar Cost per Accident	1.15	19.84	3.36
Total Fatalities	2.67	---	20.67
Average Fatalities per Accident	0.53	---	1.32
Fatal Accidents - Number	1.50	---	11.50
Fatal Accidents - Percent	0.30	---	0.74
Average Fatalities per Fatal Accident	1.78	---	1.80
Total Nonfatal Injuries	---	---	---
Average Nonfatal Injuries per Accident	---	---	---

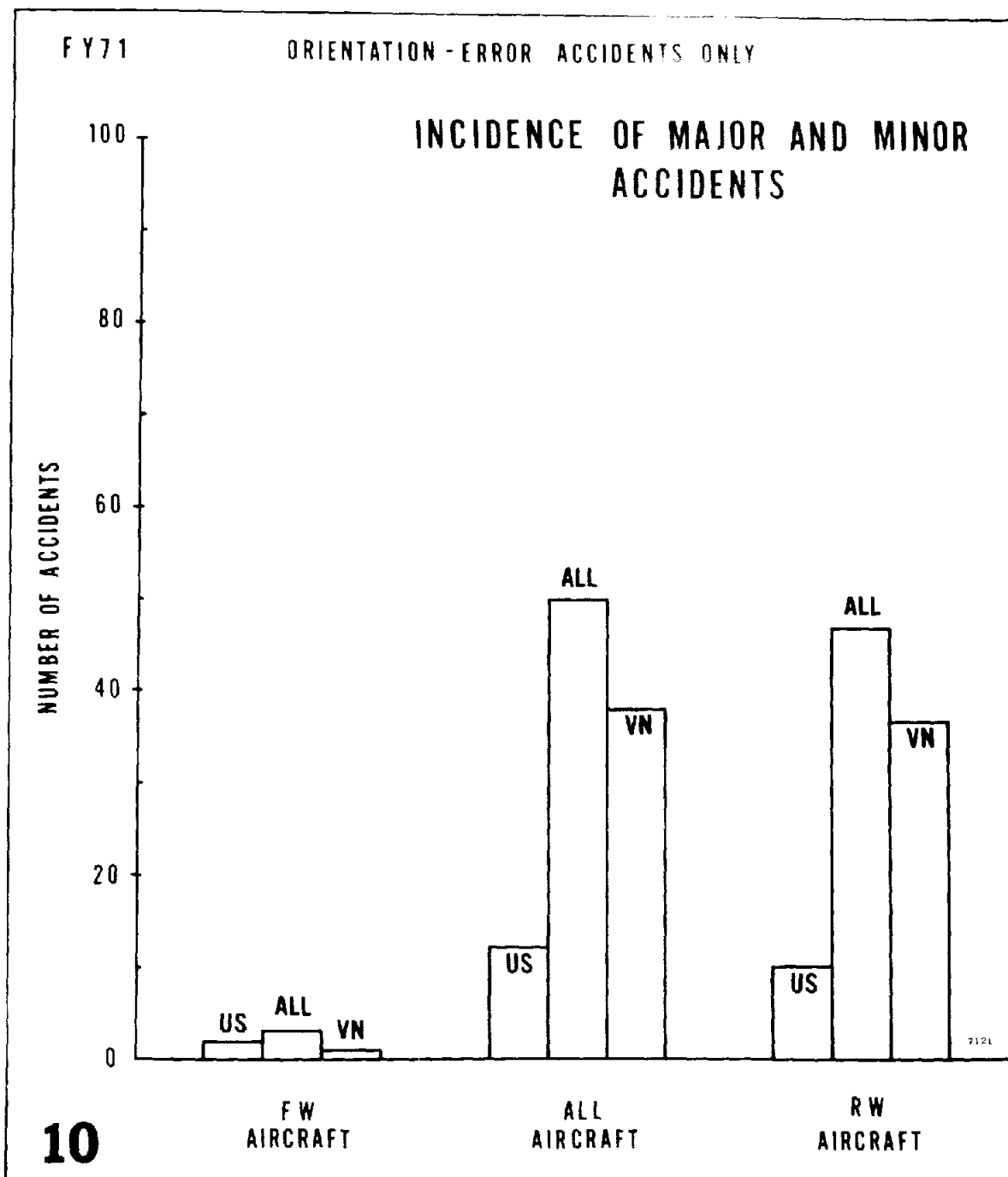


Figure 10

Orientation-Error Accident Types: Total number of major and minor orientation-error accidents located in the search of the USAAVS master accident files for fiscal year 1971. Considering all aircraft, the incidence of orientation-error accidents in VN was 3.17 times the incidence of similar accidents elsewhere. Note that the low incidence of FW accidents restricts the interpretation of VN/US or RW/FW relationships for that fiscal year.

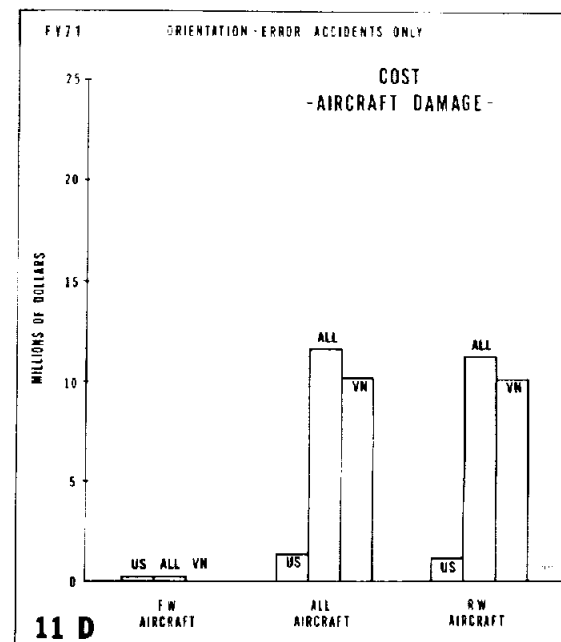
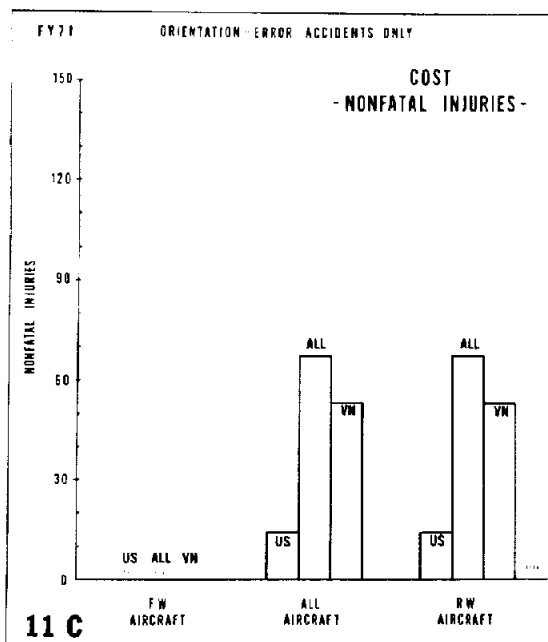
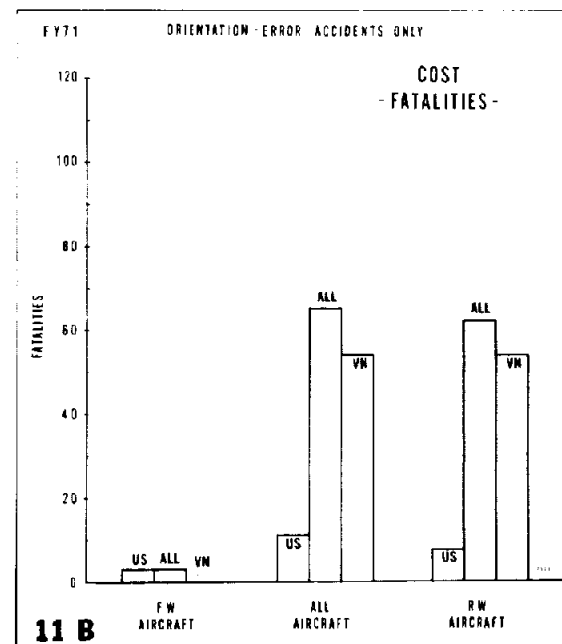
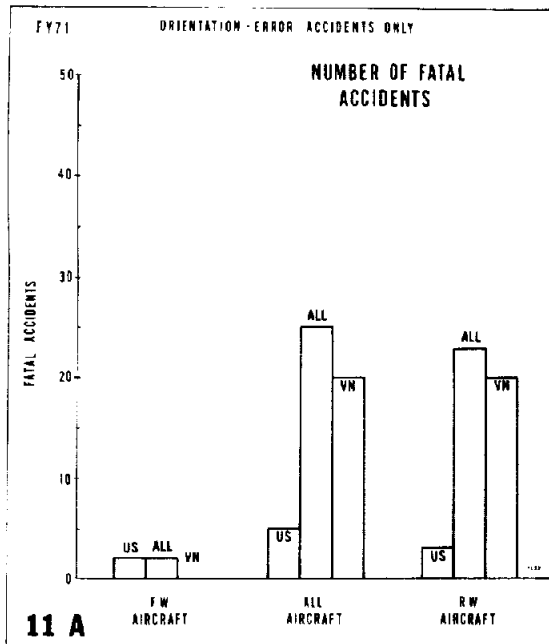


Figure 11

Orientation-Error Accident Types: Total number of fatal accidents (A), total number of fatalities (B), total number of nonfatal injuries (C), and total dollar cost of resulting aircraft damage (D) for both aircraft types and for both locations. The reader is again alerted to the low n involved in the FW data. For RW aircraft, the loss was always greatest in VN.

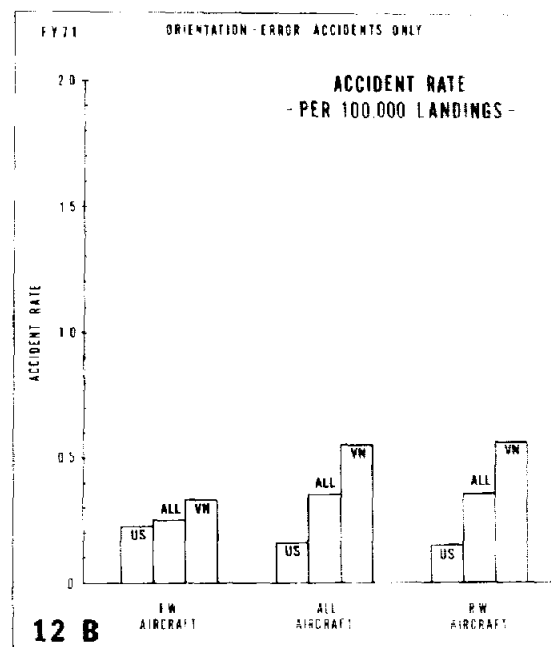
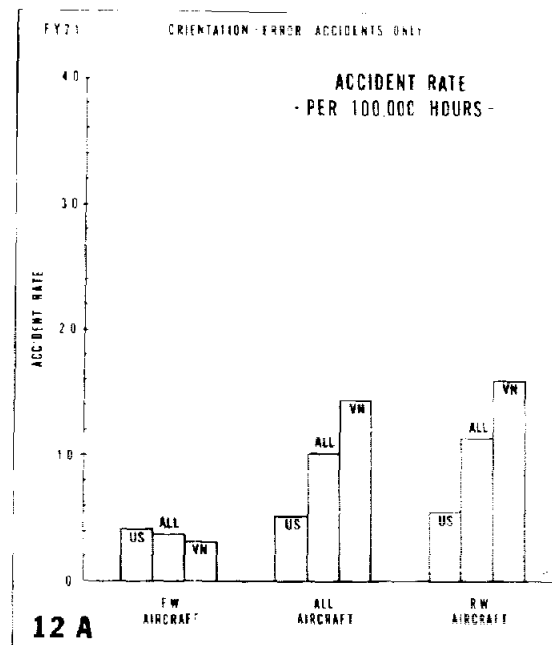


Figure 12

Orientation-Error Accident Types: Normalized incidence data showing average number of orientation-error accidents per 100,000 flying hours (A), and per 100,000 landings (B). These rate data are intended only as a fiscal year 1971 baseline reference for comparison with similar data calculated for other fiscal years of the longitudinal study. For all aircraft types, the over-all rates were 1.01 and 0.35 orientation-error accidents per 100,000 hours and per 100,000 landings, respectively.

Normalized accident rate data for these accidents are presented in Figure 12 for comparison of incidence in other fiscal years of the longitudinal study.

These data show that there were a total of 50 major and minor orientation-error accidents (25 of which were fatal), resulting in 65 fatalities, 67 nonfatal injuries, and an aircraft damage cost of \$11,404,119. The FW contribution was small involving a total of only three accidents (2 of which were fatal), 3 fatalities, no nonfatal injuries, and a total dollar cost of \$212,742. It is obvious that with such a low incidence (n) for fiscal year 1971 FW orientation-error accidents, no conclusions can be drawn as to RW/FW or US/VN accident incidence, cost, et cetera. For RW aircraft, there were a total of 47 major and minor orientation-error accidents (23 of which were fatal), resulting in 62 fatalities, 67 nonfatal injuries, and an aircraft dollar damage of \$11,191,377. Thus the majority of the orientation-error accidents involving Army Aviation aircraft occurred in RW aircraft for that fiscal year. As indicated by the RW data, the incidence and cost of accidents occurring in VN were both considerably greater than for accidents occurring elsewhere. This is particularly noticeable in the 6.67 to 1 VN/US fatal accident ratio, the 6.75 to 1 VN/US total fatality ratio, the 3.79 to 1 VN/US total injury ratio, and the 8.77 to 1 VN/US total dollar cost ratio.

The rate data in Figure 12 indicates that for FW aircraft, the over-all accident rates were 0.37 and 0.25 accidents per 100,000 hours and per 100,000 landings, respectively. For RW aircraft, the over-all rates were 1.14 and 0.36 accidents per 100,000 hours and per 100,000 landings, respectively.

COMPARATIVE INCIDENCE AND COST OF ORIENTATION-ERROR ACCIDENTS

The arrangement of the data presented in the previous sections was selected to differentiate the actual incidence and cost of all accidents, pilot-error accidents, and orientation-error accidents. In this section, selected incidence and cost data are expressed in percentage figures with the objective of gaining some insight into the relative contribution of orientation-error accidents to the over-all accident problem.

In Figure 13 the percent incidence of fatal accidents is described for all accident types, pilot-error accident types, and orientation-error accident types. The Figure 13A data show that for FW aircraft 19.54 percent of all FW accidents, regardless of accident cause or type, were fatal, with the incidence in VN being 1.21 times the incidence in US. The RW data indicate that 16.43 percent of all RW accidents were fatal, with the VN incidence about 1.40 times the US incidence. In effect, considering all accidents, little difference exists in the percent incidence of fatal accidents relative to location for either type of aircraft. Considering both aircraft types together, the totalized data of Figure 13A indicate 16.81 percent of all accidents were fatal.

The pilot-error accident data shown in Figure 13B indicates that the incidence of fatal accidents was 16.39 percent for FW aircraft and 16.38 percent for RW aircraft, a near-identical hazard. The VN/US fatal accident percent incidence ratio for RW aircraft was 1.58 to 1 as compared to a FW ratio of 0.95 to 1.

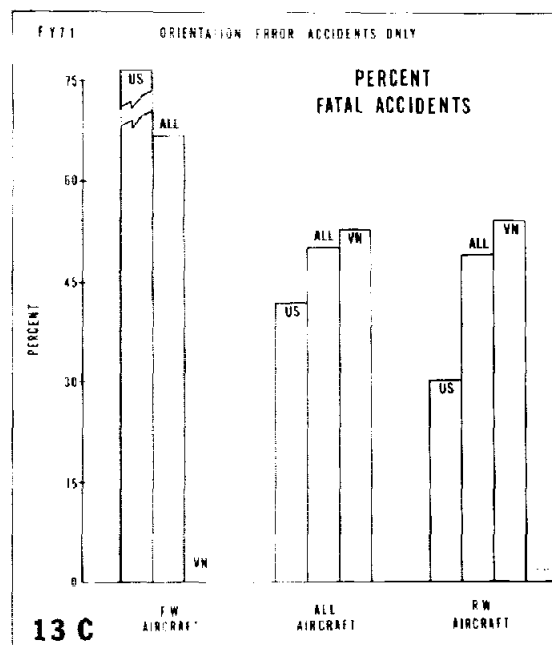
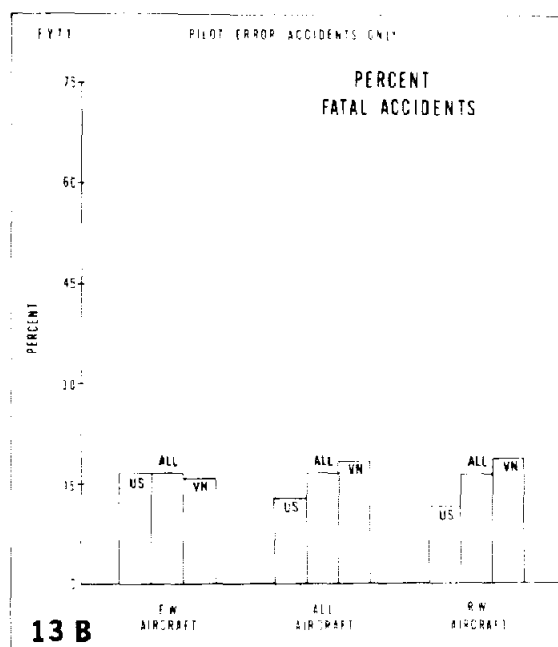
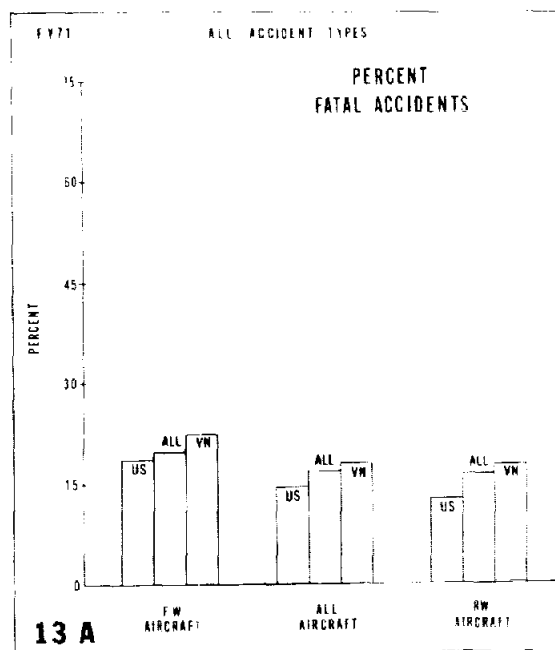


Figure 13

Comparative incidence of fatal accidents expressed as the percent of the total number of accidents within the "All Accident Type" (A), "Pilot-Error Accident Type" (B), and "Orientation-Error Type" (C) classifications that resulted in one or more fatalities. Note that orientation-error accidents had a significantly higher percentage of fatal accidents.

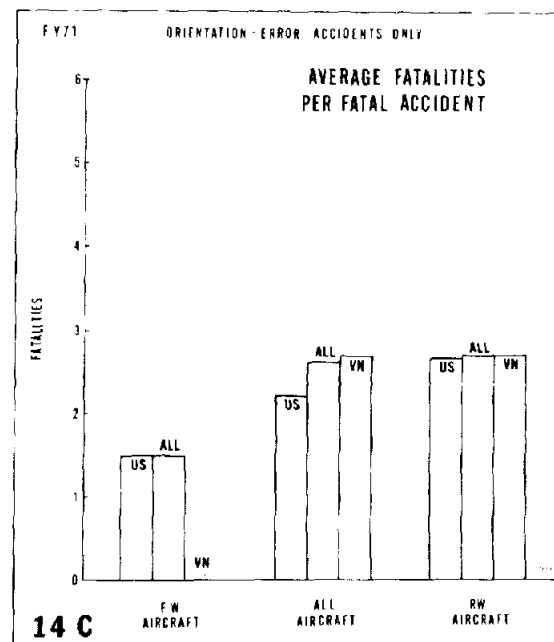
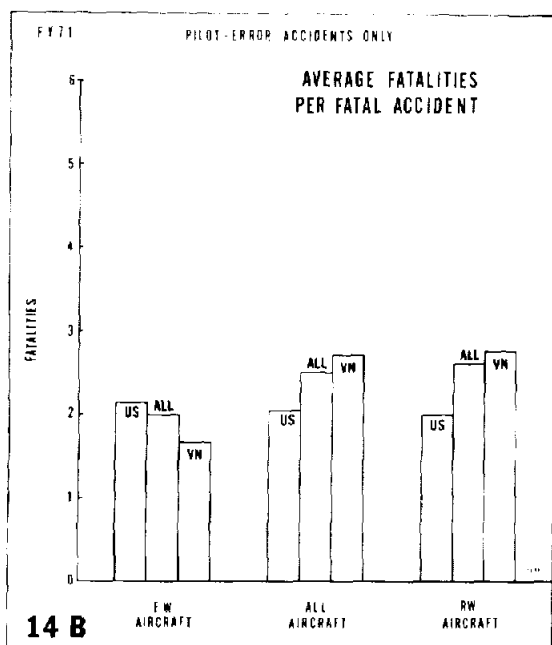
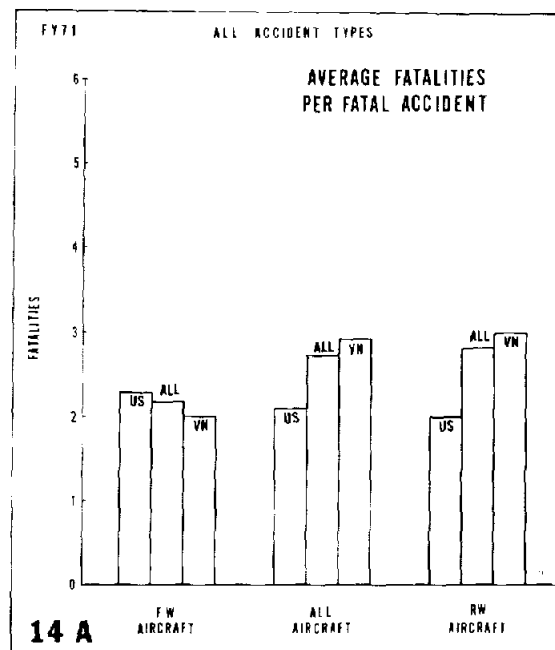


Figure 14

Average number of fatalities per fatal accident occurring within the "All Accident Type" (A), "Pilot-Error Accident Type" (B), and "Orientation-Error Accident Type" (C) classifications.

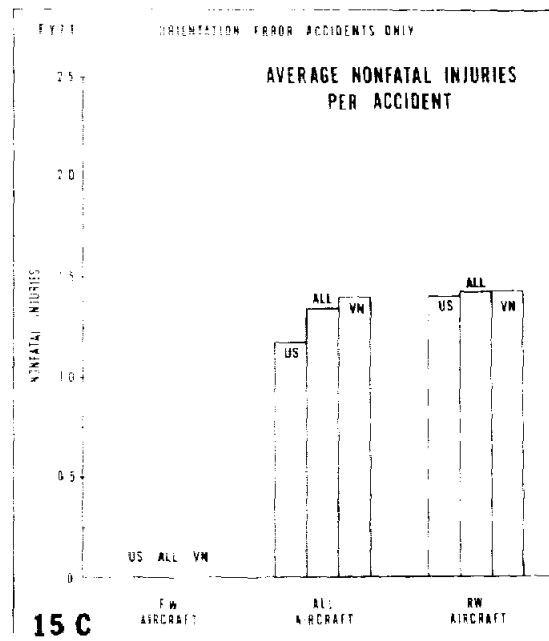
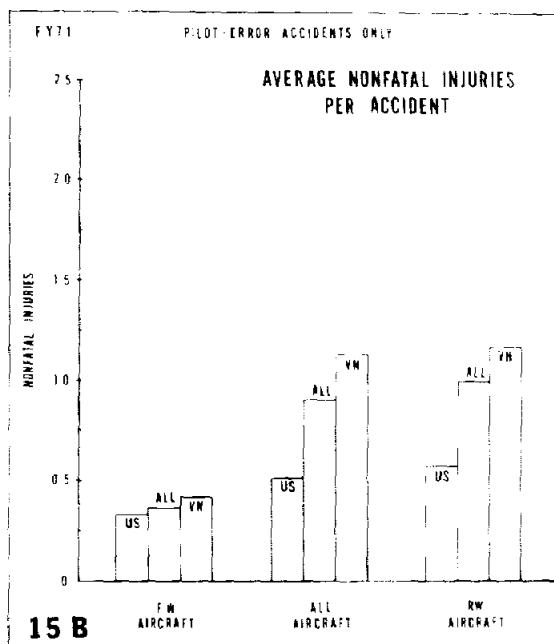
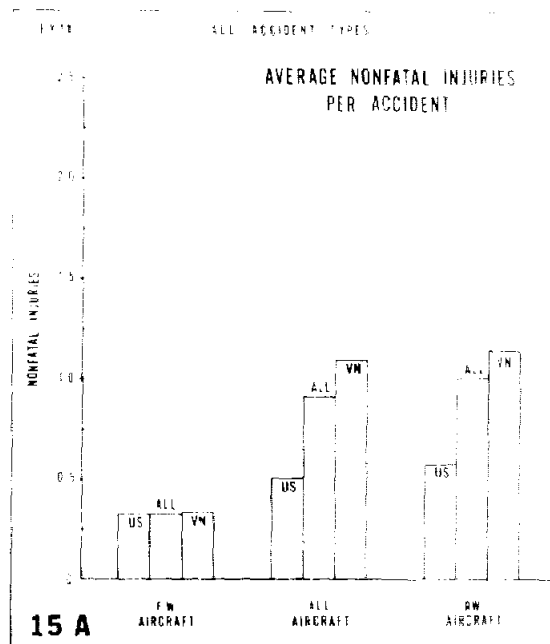


Figure 15

Average number of nonfatal injuries per accident occurring within the "All Accident Type" (A), "Pilot-Error Accident Type" (B), and "Orientation-Error Accident Type" (C) classifications.

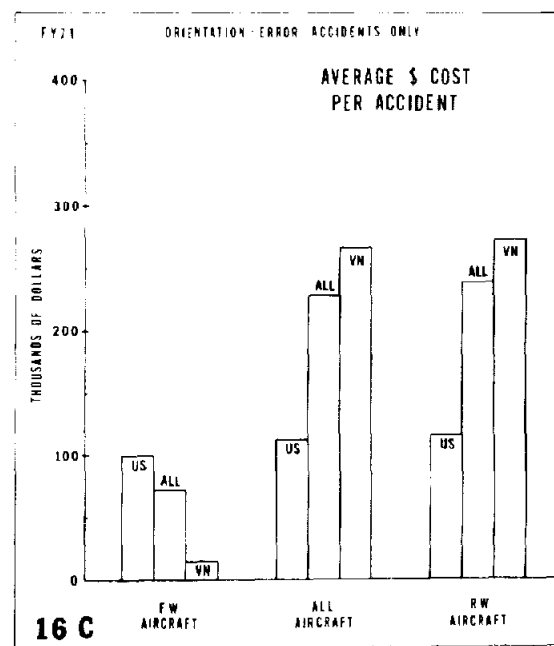
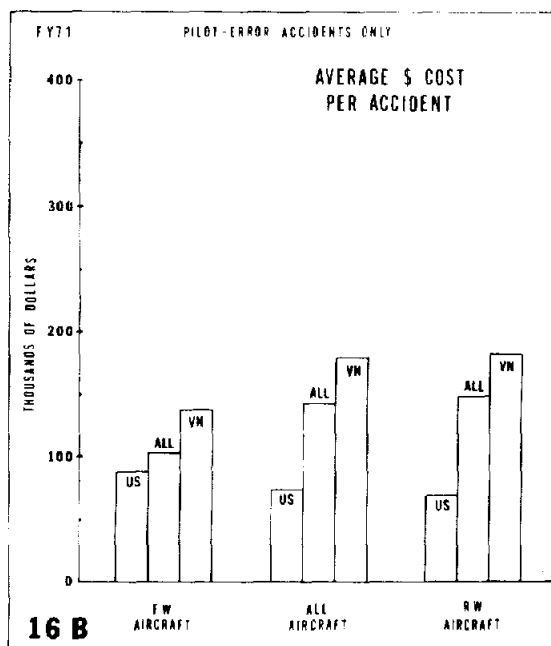
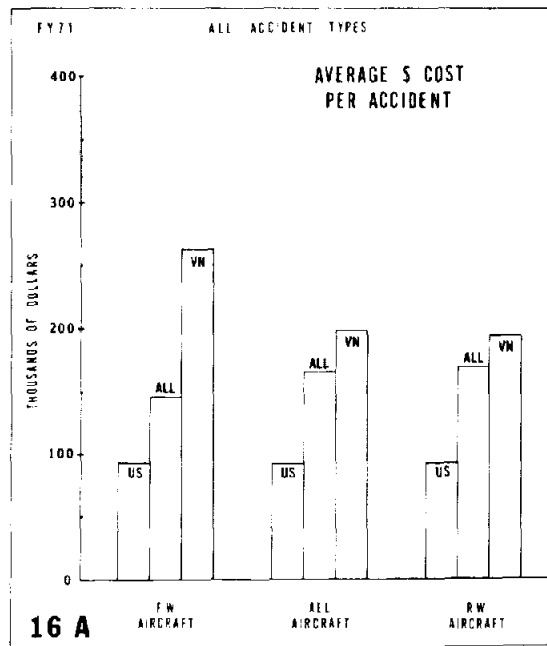


Figure 16

Average aircraft dollar damage per accident occurring within the "All Accident Type" (A), "Pilot-Error Accident Type" (B), and "Orientation-Error Accident Type" (C) classifications. The average cost was greatest for orientation-error accidents.

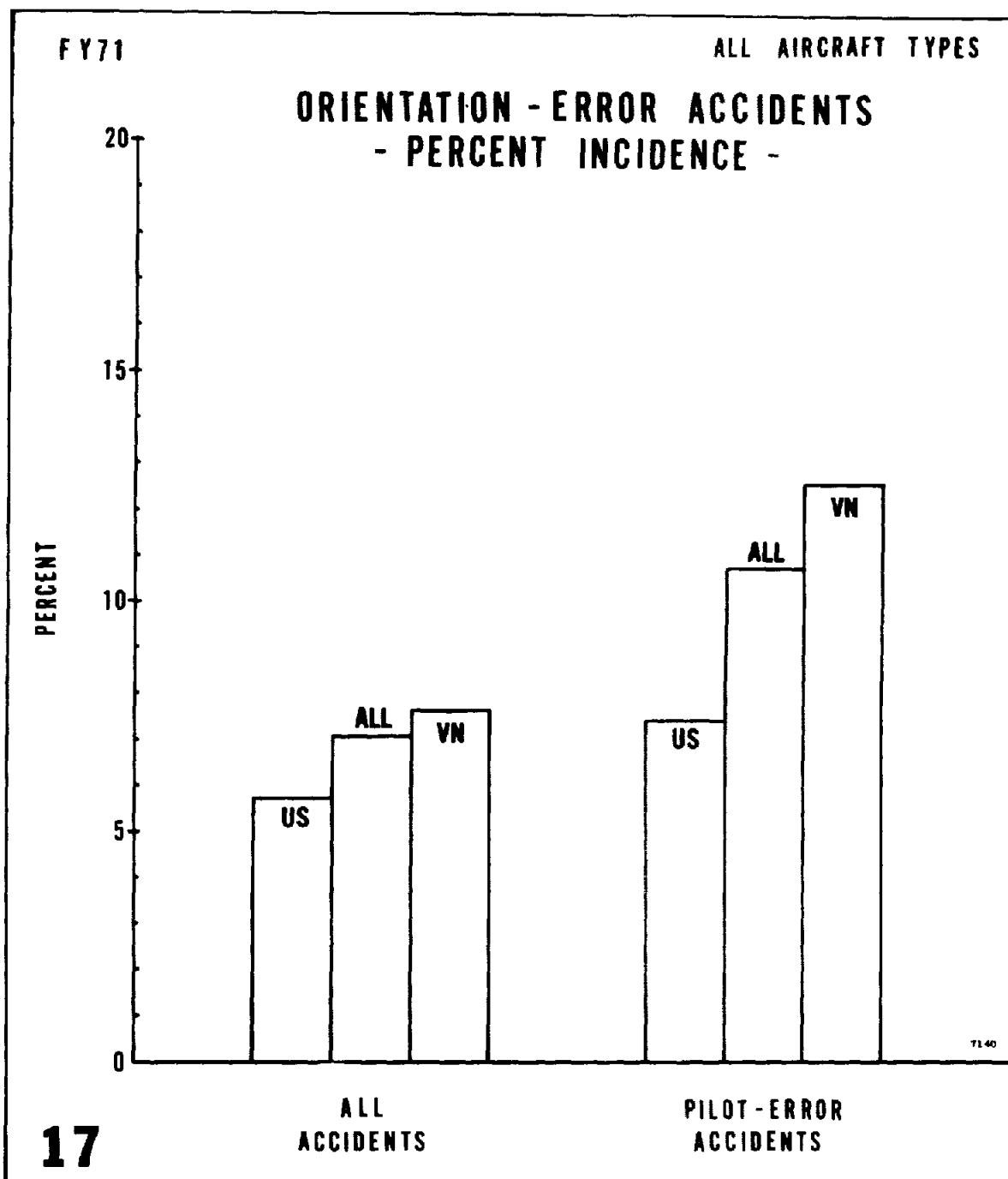


Figure 17

Percent contribution of all orientation-error accidents to the total number of accidents occurring within the "All Accident Type" and the "Pilot-Error Accident Type" classifications. Considering all types of aircraft, orientation-error accidents accounted for 7.06 percent of all accidents and 10.78 percent of all pilot-error accidents.

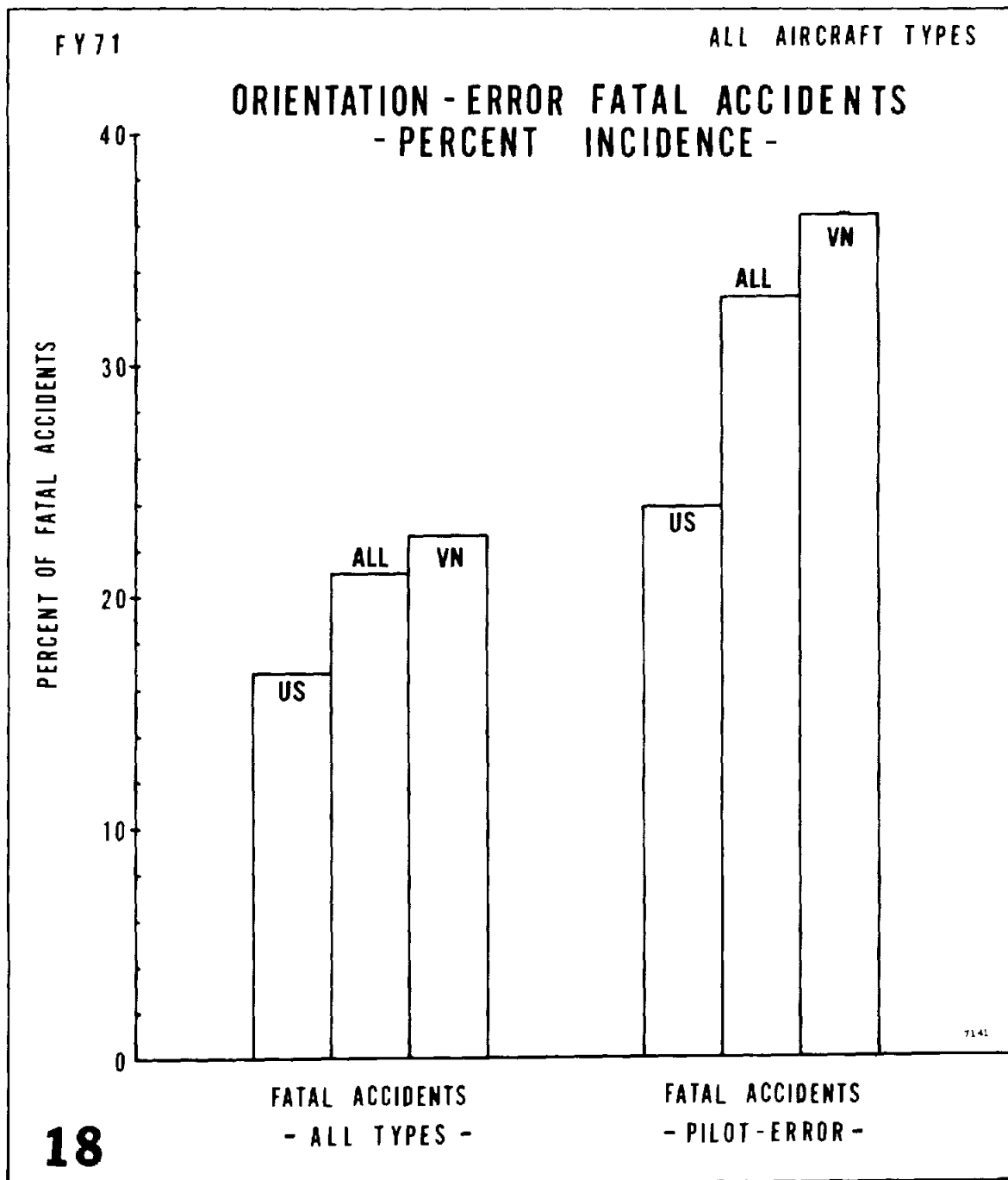


Figure 18

Percent contribution of all fatal orientation-error accidents to the total number of fatal accidents occurring within the "All Accident Type" and the "Pilot-Error Accident Type" classifications. Orientation-error accidents accounted for 21.01 percent of all fatal accidents and 32.90 percent of all fatal pilot-error accidents.

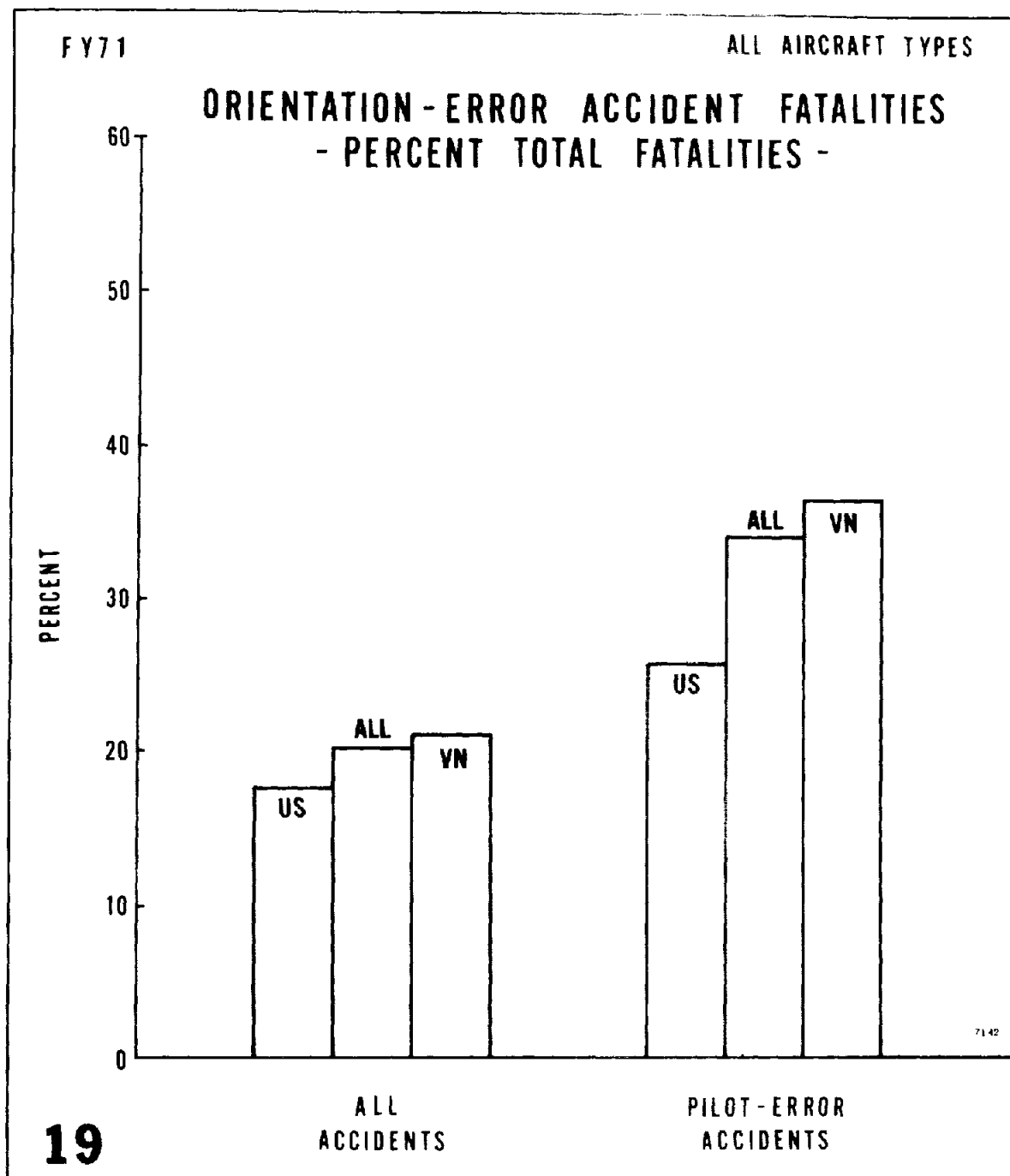


Figure 19

Percent contribution of all orientation-error accident fatalities to the total number of fatalities occurring within the "All Accident Type" and the "Pilot-Error Accident Type" classifications. Orientation-error accidents accounted for 20.06 percent of the total number of fatalities and 33.86 percent of the fatalities due to pilot-error accidents.

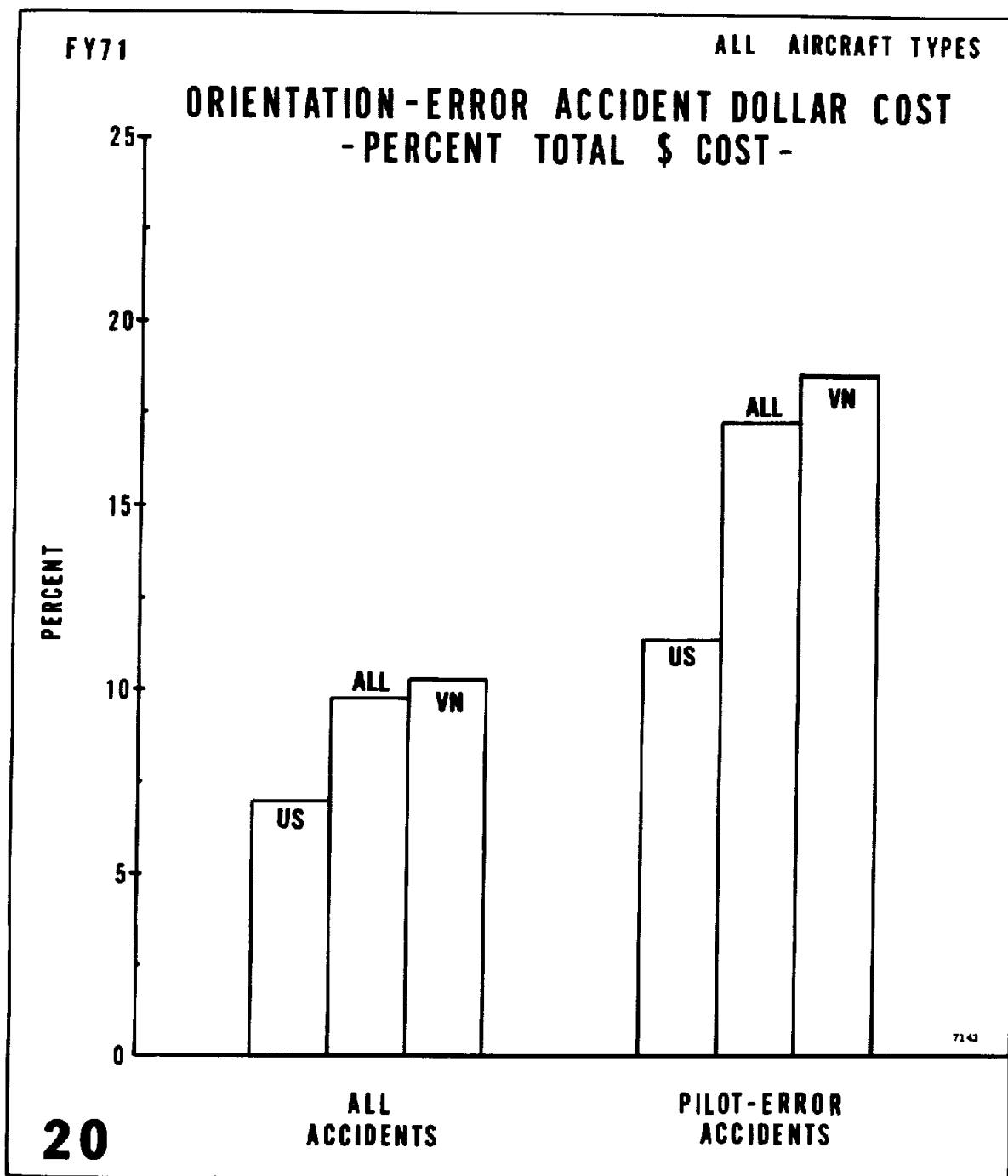


Figure 20

Percent contribution of the dollar cost of all orientation-error accidents to the total cost of all accidents occurring within the "All Accident Type" and "Pilot-Error Accident Type" classifications. Orientation-error accidents accounted for 9.7 percent of the total cost of all accidents and 17.25 percent of the cost of all pilot-error accidents.

For orientation-error accidents, however, the probability of a fatal accident was much higher, as shown in Figure 13C. Again, the reader is cautioned to remember the low incidence of FW accidents for this period. Since both accidents that occurred in US were fatal, this accounts for the 100 percent datum drawn in Figure 13C. Thus for fiscal year 1971, the relative incidence and cost of orientation-error accidents derived predominantly from RW accidents. In the remaining orientation-error figures then, the "All Aircraft" data will, in essence, be identical to the "RW Aircraft" data. The percent incidence of fatal accidents when orientation error was involved rose to 52.63 percent in VN and 41.67 percent in US.

Similar comparisons for the three classes of accidents are made in Figure 14 for the average number of fatalities per fatal accident. The same format is used in Figure 15 to depict the average number of nonfatal injuries that occurred per accident. In terms of the average dollar cost data presented in Figure 16, orientation-error accidents resulted in the greatest loss.

Figures 17 through 20 illustrate the relative contribution of orientation-error accidents in all aircraft types to selected incidence and cost data as a given percentage of corresponding statistics for both "all accident types" and "pilot-error accident types." In Figure 17, orientation-error accidents are shown to represent 7.06 percent of all accidents that occurred during this year and 10.78 percent of all pilot-error accidents. When one considers the number of fatal accidents that occurred in the two accident groups, as is done in Figure 18, orientation-error fatal accidents represent 21.01 percent of all fatal accidents and 32.90 percent of all fatal pilot-error accidents. In terms of fatalities, orientation-error accidents resulted in 20.06 percent of the total number and 33.86 percent of those occurring in pilot-error accidents, as indicated in Figure 19. Lastly, orientation-error accidents accounted for over 9.70 percent of the total cost of all accidents and 17.25 percent of the cost of all pilot-error accidents, as shown in Figure 20.

This report completes the compilation of accident incidence and cost data for the fiscal years 1967 through 1971 period. A final report will be prepared to summarize the over-all findings of this five-year longitudinal study of orientation-error accidents in Regular Army aircraft.

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